

Historic, Archive Document

Do not assume content reflects current scientific knowledge, policies, or practices.

JAN 27 1965

CURRENT SERIAL RECORDS

VEGETABLE RESEARCH

of the

United States Department of Agriculture
and Cooperating Agencies

This progress report of U.S.D.A. and cooperative research is primarily a tool for use of scientists and administrators in program coordination, development and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

The summaries of progress on U.S.D.A. and cooperative research include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed, will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members, and others having an interest in the development of public agricultural research programs.

This report also included a list of publications reporting results of U.S.D.A. and cooperative research issued during the past year. Current agricultural research findings are also published in the monthly U.S.D.A. publications, Agricultural Research, Agricultural Marketing, and The Farm Index.

UNITED STATES DEPARTMENT OF AGRICULTURE
Washington, D. C.
December 31, 1964



ADVISORY COMMITTEES

The research program of the Department of Agriculture is reviewed annually by the following advisory committees:

1. Farm Resources and Facilities Research
2. Utilization Research and Development
3. Human Nutrition and Consumer Use Research
4. Marketing Research
5. Agricultural Economics Research
6. Forestry Research
7. Animal and Animal Products Research
8. Cotton Research
9. Grain and Forage Crops Research
10. Horticultural Crops Research
11. Oilseed, Peanut and Sugar Crops Research
12. Plant Science and Entomology Research
13. Tobacco Research

ORGANIZATIONAL UNIT PROGRESS REPORTS

The source materials used by the advisory committees are of two types. First there are Organizational Unit Reports that cover the work of the Divisions or Services listed below. The number prefixes refer to advisory committees listed above that review all of the work of the respective Divisions or Services.

Agricultural Research Service (ARS)

- 1 - Agricultural Engineering
- 1 - Soil and Water Conservation
- 2 - Utilization -- Eastern
- 2 - Utilization -- Northern
- 2 - Utilization -- Southern
- 2 - Utilization -- Western
- 3 - Human Nutrition
- 3 - Clothing and Housing
- 3 - Consumer and Food Economics
- 4 - Market Quality
- 4 - Transportation and Facilities
- 7 - Animal Husbandry
- 7 - Animal Disease and Parasite
- 12 - Crops
- 12 - Entomology

Economic Research Service (ERS)

- 1, 5 - Resource Development Economics
- 4, 5 - Marketing Economics
- 5 - Farm Production Economics
- 5 - Economic and Statistical Analysis
- 5 - Foreign Development and Trade Analysis
- 5 - Foreign Analysis Division

Forest Service - Research (FS)

- 6 - Forest Economics and Marketing
- 6 - Forest Products and Engineering
- 6 - Forest Protection
- 6 - Timber Management
- 6 - Watershed, Recreation and Range

Other Services

- 4, 5 - Farmer Cooperative Service (FCS)
- 4, 5 - Statistical Reporting Service (SRS)

SUBJECT MATTER PROGRESS REPORTS

The second type of report brings together the USDA program and progress for the following commodities and subjects:

- | | |
|--|--------------------------------------|
| 3 - Rural Dwellings | 8 - Cotton and Cottonseed |
| 6 - Forestry (Other than Forest Service) | 9 - Grain and Forage Crops |
| 7 - Beef Cattle | 10 - Citrus and Subtropical Fruit |
| 7 - Dairy | 10 - Deciduous Fruit and Tree Nut |
| 7 - Poultry | 10 - Potato |
| 7 - Sheep and Wool | 10 - Vegetable |
| 7 - Swine | 10 - Florist, Nursery and Shade Tree |
| 7 - Cross Species and Miscellaneous | 11 - Oilseeds and Peanut |
| Animal Research | 11 - Sugar |
| | 13 - Tobacco |

A copy of any of the reports may be requested from Barnard Joy, Research Program Development and Evaluation Staff, U. S. Department of Agriculture, Washington, D. C. 20250.

C O N T E N T S

Introduction	vi
I. FARM RESEARCH	
Crop Introduction and Evaluation	1
Sweetpotato Culture, Breeding, Diseases and Variety Evaluation	5
A. Breeding	6
B. Diseases	7
C. Variety and Selection Evaluation	8
Onion, Carrot and Other Root and Bulb Culture, Breeding, Diseases and Variety Evaluation	10
A. Breeding	11
B. Diseases	13
Peas and Bean Culture, Breeding, Diseases and Variety Evaluation	14
A. Breeding	16
B. Diseases	19
Tomato, Pepper, and Related Crop Culture, Breeding and Genetics, Diseases and Variety Evaluation	24
A. Breeding	26
B. Genetics	28
C. Diseases	28
D. Culture	29
Leafy and Miscellaneous Vegetables	31
A. Breeding	33
Melon and Other Cucurbit Culture, Breeding and Genetics, Diseases and Variety Evaluation	37
A. Breeding	39
B. Diseases	40
Mushroom Breeding and Genetics, Disease and Culture	44
Seed Crop Culture, Physiology, Nutrition and Harvesting	46
Weed and Nematode Control	49
A. Weed Investigations	50
B. Nematodes	52
Insect Control	54
A. Basic Biology, Physiology, and Nutrition	55
B. Insecticidal and Cultural Control	58
C. Insecticide Residue Determinations	59
D. Biological Control	60
E. Insect Sterility, Attractants, and Other New Approaches to Control	61
F. Evaluation of Equipment for Insect Detection and Control	62
G. Varietal Evaluation for Insect Resistance	64
H. Insect Vectors of Diseases	65
Pest Control Techniques and Equipment	68
Electromagnetic and Ultrasonic Energy for Insect Control	73
Electric and Solar Equipment for Environmental Control	77

II. NUTRITION, CONSUMER AND INDUSTRIAL USE RESEARCH

Eastern Utilization Research and Development Division	80
A. New and Improved Dehydrated Products	82
B. New and Improved Processing Technology	82
Southern Utilization Research and Development Division	83
A. Chemical Composition and Physical Properties	86
B. New and Improved Food Products	87
C. New and Improved Processing Technology	89
Western Utilization Research and Development Division	92
A. Chemical Composition and Physical Properties	95
B. New and Improved Food Products and Processing Technology	100
Nutrition and Consumer Use Research	107
A. Nutrient Value of Food	109
B. Nutritional Evaluation of Vegetables	110
C. Properties Related to Quality and Consumer Use of Vegetables ..	111
D. Food Consumption and Diet Appraisal	112

III. MARKETING AND ECONOMIC RESEARCH

Market Quality	118
A. Objective Measurement of Quality	119
B. Quality Maintenance in Handling and Packaging	120
C. Quality Maintenance in Storage	121
D. Quality Maintenance During Transportation	121
E. Postharvest Physiology	122
F. Postharvest Disease Control	123
Transportation and Marketing Facilities	128
A. Handling and Packing Vegetables	130
B. Cooling	131
C. Handling Vegetables in Pallet Boxes	132
D. Handling and Packing Fruits and Vegetables on Terminal Markets	133
E. Consumer Packages and Shipping Containers	133
F. Transport Equipment	136
G. Transport Techniques	138
Cooperative Marketing	141
Economics of Marketing	144
A. Structure, Practices and Competition	145
B. Information, Outlook and Rural Development	147
C. Margins, Costs and Efficiency	147
D. Market Potentials	147
E. Transportation	148
Economic and Statistical Analysis	151
Consumer Preference and Quality Discrimination	153
Improvement of Crop Estimating Procedures	155

INTRODUCTION

This report deals with research on all the vegetables except white or Irish potatoes. It does not include extensive cross-commodity work, much of it basic in nature, which contributes to the solution of problems of agricultural commodities, as well as those of vegetables. The progress in cross-commodity work is found in the organizational unit reports of the several research divisions of the Department.

This report is organized by problem areas which are shown as the major subjects under the three main divisions in the table of contents. For each of the problem areas there is a statement of (1) the Problem, (2) USDA AND COOPERATIVE PROGRAM, (3) PROGRAM OF STATE EXPERIMENT STATIONS, (4) PROGRESS--USDA AND COOPERATIVE PROGRAMS, (5) PUBLICATIONS--USDA AND COOPERATIVE PROGRAMS.

Research on vegetable problems is supported by (1) Federal funds appropriated to the research agencies of the USDA, (2) Federal and State funds appropriated to the research agencies of the USDA, and (3) private funds for research carried on in private laboratories or for support of State Station or USDA work.

Research by USDA

Farm Research comprises investigations on introduction, breeding and genetics, variety evaluation, culture, diseases, nematodes, weed control, insects, crop pest control techniques and equipment and electromagnetic and ultrasonic energy for insect control and other farm uses. This research is conducted by the Crops, Entomology, and Agricultural Engineering Divisions of the Agricultural Research Service.

Nutrition, Consumer and Industrial Use Research. Nutrition and consumer use research pertains to composition and nutritive value; physiological availability of nutrients and their effects; and new and improved methods of preparation, preservation and care in homes, eating establishments, and institutions. This work is done by the Divisions of Human Nutrition Research and Consumer and Food Economics Research of the Agricultural Research Service. Utilization research deals with methods of preservation of these commodities through canning, drying, freezing, or combination of these commodities through canning, drying, freezing, or combinations of these methods and also with the origination of new forms of food products or combinations of vegetables with other foods. It is also concerned with improved equipment and processes. The work is conducted by the Eastern Utilization Research and Development Division, Wyndmoor, Pennsylvania; the Southern Utilization Research and Development Division, New Orleans, Louisiana; the U. S. Fruit and Vegetable Laboratories at Weslaco, Texas, and Winter Haven, Florida; the U. S. Food Fermentation Laboratory, Raleigh, North Carolina; the Western Utilization Research and Development Division, Albany, California; the Fruit and Vegetable Products Laboratories at Puyallup and Prosser, Washington; and the Fruit and Vegetable Chemistry

Laboratory at Pasadena, California, and under contract with State and foreign country laboratories and in cooperation with the industry and other organizations mentioned under Program for each research area.

Marketing and Economic Research. Marketing research involves the physical and biological aspects of assembly, packaging, transporting, storing, and distribution from the time the product leaves the farm until it reaches the ultimate consumer. The work reported herein is conducted by the Market Quality and the Transportation and Facilities Research Divisions of the Agricultural Research Service. Economic research is concerned with marketing costs, margins, and efficiency; market potential, supply and demand; outlook and situation; and improving marketing through research with farmer cooperatives. The work reported herein is done by the Economic and Statistical Analysis and the Marketing Economics Research Divisions of the Economic Research Service; by the Standards and Research Division of the Statistical Reporting Service; and by the Marketing Division of the Farmer Cooperative Service.

Interrelationships Among Department, State and Private Research

Much of the Department's research is cooperative with State Experiment Stations, various sectors of industry and with growers. Cooperative work is jointly planned and frequently participated in by Federal, State and industry workers. The nature of the cooperation varies with each study. It is developed to fully utilize the personnel and other resources of the cooperators. There is regular exchange of information between State and Department scientists to assure that the research programs complement each other and eliminate undesirable duplication. Many Department employees are located at State Stations and use laboratories and office space close to, or furnished by, the State.

Privately supported research of considerable extent is done by food processors and distributors, food industry and trade associations, seedsmen, chemical and fertilizer companies, marketing equipment and facility manufacturers, package and container manufacturers, market research institutes and corporations and growers (individually and through their associations). Industry's cooperation in supporting research on vegetables in the form of grants, gifts or loans of materials, equipment and facilities at Federal and State Stations has contributed greatly to its success.

A number of food processing companies and wholesale and retail distributors are presently conducting research in various phases of products and process development in frozen, canned, and dried vegetable products. The canning freezing and dehydrating industries each maintain an association with a technical staff and either do research in their own laboratories or support research at USDA laboratories, universities, and other organizations. Allied industries and suppliers to the food processing industry maintain excellent laboratories and large research staffs to provide technical information to the industry.

Marketing equipment and facility manufacturers also make sizeable contributions to research on the development of equipment for handling vegetables on the farm, into and out of packing houses, transportation vehicle, wholesale distribution center and in the retail establishment as well as research on the containers in which they are moved and on the transportation vehicles from which they move from one point in the distribution channel to another. Market research institutes and others in marketing economics research are largely concerned with research in consumer preference, market potentials, market promotion and development, and inter-regional and intermarket competition.

Chemical and fertilizer companies are significant factors in research on the development of new materials or combinations of materials to produce more efficiently, high quality vegetables through better nutrition of the growing plant, control of diseases, insects, nematodes, weeds, killing of tops, and protective waxes.

Several of the large vegetable seed producers and some of the vegetable processors have staffs of scientifically trained and competent plant breeders, seed technologists and horticulturists who are capable of using the basic research results and disease and insect resistant breeding stocks produced in Federal and State laboratories, in the production of commercial varieties locally, regionally, or nationally adapted. In time it should, therefore, be possible for public agencies to restrict their work on the production of finished varieties of vegetables and to shift the resources now employed in breeding varieties to more of the fundamental work on isolating resistance factors, determining the manner of their inheritance and on the development of breeding methods to most efficiently use them.

It is very difficult to estimate the contribution of growers to our overall research effort on vegetables. Certainly, in the field of production his help is indispensable for most of the laboratory and trial ground research results must finally be confirmed by field experiments. The grower cooperates with the USDA, State Experiment Stations and suppliers of many materials and equipment; usually, without compensation except for the experience and knowledge gained.

Examples of Recent Research Accomplishments by USDA and Cooperating Scientists

Difficult Genetic Linkage Broken in Tomato. For many years successful development of varieties of tomato resistant to tobacco mosaic virus disease, a very common and often serious malady, has been stalled by a very close genetic linkage between the genes for resistance and the genes causing a disastrous chlorophyll deficiency in the young tomato plants. Through a stepped-up breeding effort this linkage has been finally "broken" and the way is clear for final development of TMV-resistant tomato varieties free of the objectionable "virescent" character. Several promising lines are

under study. The resistance was obtained from a wild relative of the tomato introduced from South America by our Plant Introduction explorers many years ago.

New Dehydrated Vegetable Product Produced Commercially. The explosive puffing process developed by Division engineers for preparing dehydrated vegetables capable of reconstitution in from one-fifth to one-tenth the usual time has been commercialized. A large manufacturer of dehydrated vegetables in California is now selling 3/8-inch carrot dice made by this new explosive puffing process. This product can be reconstituted by simmering for 5 minutes instead of the usual 40 minutes required for conventionally dried pieces of the same size. According to the manufacturer, "Recent evaluations of 'pilot runs' made in 1962 and production runs made in 1963 have shown that development of certain flavors and aromas that are characteristic of aging in conventionally dried carrots are greatly reduced in the 'Puffed Dried' (explosion puffed) carrots." Also, explosive puffing permits making larger dehydrated pieces than is feasible by conventional hot air drying. The process is extending the use of vegetables in dehydrated soups, stews and other products for civilian and military use.

Better Frozen Fruits and Vegetables. While conventional freezing processes usually preserve the flavor, color, and nutritive value of frozen fruits and vegetables, they often have an adverse effect on texture. In common commercial practice freezing requires from 15 minutes to many hours. The scientists found that if freezing is accomplished very rapidly--in a minute or less--such damage does not occur. Green beans frozen by intermittent immersion in liquid nitrogen, for example, have a texture essentially the same as that of fresh beans. Freezing with liquid nitrogen is probably too costly for all but high-valued products. However, other less expensive ways of achieving very rapid freezing are available and they will undoubtedly come into much wider use now that the improvement in product quality has been demonstrated. Retention of fresh-product texture in the processed product will expand the market for frozen fruits and vegetables.

Heat Treatment for Control of Decay of Fresh Fruits and Vegetables. Although heat has been used to a limited extent to control certain plant diseases for many years, the recent concern regarding chemicals in foods has stimulated research with heat as a method of decay control. Following promising results obtained by the Department with hot water treatment of peaches (published in MRR 643) one large peach grower in Georgia successfully treated his entire crop in 1964. A very large packing house in South Carolina has also installed a heat-treating tank in the packing line. There is also a successful commercial application in Florida of the hot water treatment for the control of anthracnose decay of mangos. Promising results are being obtained experimentally with hot water for control of decay of bell peppers and citrus fruits and with hot air for control of decays of strawberries, red raspberries, and blueberries.

Irradiation. Placement of a mobile gamma irradiator at the Fresno field laboratory during the past fiscal year enabled evaluation of this treatment for a wide range of horticultural crops, field crops, meats, poultry, and stored product insects under semi-commercial conditions. Postharvest decay reduction, without serious adverse effects on the quality of the commodity, was obtained with fresh strawberries, nectarines, figs, and mushrooms. Most of the other horticultural commodities treated showed adverse effects on texture, color, or flavor at irradiation dosages producing worthwhile decay reduction. With this information producers and shippers of horticultural crops can better assess the commercial possibilities of the irradiation treatment.

Prepackaging Western Lettuce at Shipping Point. When lettuce is prepackaged at shipping point about one-third of the weight of the lettuce is eliminated by the removal of the wrapper leaves and about 30 cents per box is saved on transcontinental shipments. Prepackaged lettuce shipped to eastern markets arrived in a condition comparable to the conventionally packed lettuce. It is estimated that if only one-half of the rail shipments were shipped prepackaged, the freight saving would exceed 6 million dollars per year.

The professional staff of the Division is much too small to give adequate attention to the problems now being studied and to undertake other new and urgent research represented by pending proposals. Technology is changing rapidly in the physical elements and methods applicable to marketing operations. It is important that the application of new technology be explored before, instead of after, major investments are made in new plants and equipment, if costly mistakes are to be avoided.

Development of Design for Multi-Purpose Van Container. A design for a multi-purpose van container for transporting farm and food products has been developed. When completed, the van can haul frozen and nonfrozen products as well as dry cargo. It can be moved by highway, rail, water, and possibly air. When widely adopted, and industry interest indicates it will be, the van container will bring significant reduction in the annual bill for transporting agricultural products and supplies, and at the same time furnish better protection to products which require special environment during transit.

Philadelphia Food-Distribution Center Nearing Completion. In Philadelphia, as a result of studies of the facilities used for handling food, construction is almost complete on the 388-acre food-distribution center. When completed, the development will represent an investment of over \$100 million and provide employment for about 12,000 people in handling and processing all types of food and food products and related service industries. Prior to the development of the center, the tax income from the site was \$29,000 per year and when construction is completed, will be almost \$2.0 million annually. The old market has been replaced with three apartment buildings and a number of townhouses, increasing the assessed valuation from about \$7.0 to \$27.0 million.

7. Promotional Expenditures by Producer Organizations. -- A survey of promotional expenditures of producer organizations and similar agriculturally oriented groups indicates that there are almost 1,200 of these organizations spending a total of about \$86 million annually for the promotion of agricultural products. This is an increase of nearly \$20 million over expenditures shown by these organizations in a similar survey in 1958. This increase in expenditures represents added self-help efforts by producer groups to build and strengthen markets for their products and to combat the problem of an imbalance between demand and supply. Fruit, which was the leading product promoted, and dairy, which ranked second, accounted for well over 50 percent of these expenditures. Meat and livestock products ranked third with expenditures of over \$6 million per year. Promotional expenditures for natural fibers, poultry and eggs, and field crops were comparable ranging between \$4 and \$5 million per year for each commodity class.

Voluntary producer-processor groups spent more than any of the other groups, with expenditures of nearly \$32 million per year. Cooperatives and commissions and boards operating under enabling legislation were also important, with each type of organization spending about \$25 million per year. State Departments of Agriculture and other organizations not identified spent less than the other types of organizations, with expenditures in each of these categories averaging about \$1.5 million per year.

I. FARM RESEARCH

CROP INTRODUCTION AND EVALUATION Crops Research Division, ARS

Problem. American agriculture is based on the expanding culture of crops most of which have originated outside our continental limits. The improvement of existing crop varieties, the selection of new lines with natural resistance to insects and diseases, and the development of any number of important characteristics is dependent on a continuous flow of introduced germ plasm. Inherent in this is the preliminary evaluation and cataloging of plant introductions for traits which will be of use to plant breeders and the agronomic development of potential crops as a result of joint botanical-utilization screening research on new crops. These demands require the search for and introduction of 8 to 10 thousand plant collections and samples for analysis yearly.

USDA AND COOPERATIVE PROGRAM

The nature of this program is to conduct investigations concerned with the introduction, evaluation, and maintenance of plant germ plasm for the development of a strong yet diversified agricultural program for the United States. Research involves a continuing assessment of the world's plant resources; procurement of stocks through exploration and international exchange; the evaluation of the introductions either as breeding stocks, as potential new crops, or for land reclamation and conservation purposes, through a national cooperative research effort, and the preservation of these materials either as seed or as vegetative stocks. Leadership for this program is at Beltsville, Maryland.

Four national introduction stations are responsible for evaluation, maintenance, and/or quarantine of new introductions which require special handling: Chico, California; Miami, Florida; Savannah, Georgia; and Glenn Dale, Maryland. The responsibility for preservation of seed stocks of national interest lies with the National Seed Storage Laboratory, Fort Collins, Colorado. Cooperative new crops studies to determine significant agronomic characteristics of plants having valuable end-products are conducted cooperatively with experiment stations of Alabama, Montana, Nebraska, North Carolina, South Carolina, and Texas. Four regional and one inter-regional introduction stations deal with the evaluation of crop breeding stocks essential to programs in state experiment stations.

Ten P.L. 480 projects are currently active, all having to do with the collection and screening of native plants of potential use in the agriculture of the United States. These countries and grant amounts are as follows: Colombia (S5-CR-1) - \$113,159; India (A7-CR-52) - \$20,752; Israel (A10-CR-10) - \$115,555; Israel (A10-CR-11) - \$87,337; Korea (A13-CR-1) - \$46,692; Pakistan (A17-CR-5) - \$60,449; Spain (E25-CR-11) - \$156,583; Turkey (A22-CR-1) - \$134,444; Uruguay (S9-CR-3) - \$114,024; Yugoslavia (E30-CR-2) - \$30,000.

The Federal scientific effort devoted to research in New Crops totals 38.5 man-years. Of this number, 3.0 are devoted to international plant exchange, 3.2 to botanical investigations, 6.2 to special plant procurement and botanical activities. Research on new crop evaluation includes 8.7 man-years for horticultural research, 3.8 for agronomic studies, 6.1 devoted to evaluation of potential new crops, 4.0 to pathology, and 3.5 to maintenance of germ plasm.

PROGRAM OF STATE EXPERIMENT STATIONS

While responsibility for collecting and introducing plant material into this country rests predominantly with the Department, the State stations cooperate actively in the preservation, multiplication, and preliminary evaluation of such materials and in domestic and other explorations for the introduction of new materials. An elaborate system supported in part by the States and in part by the Department has been organized for the purpose of placing introduced materials in the hands of interested plant researchers throughout the country. This system consists of a series of 5 plant introduction stations located respectively in Geneva, New York; Experiment, Georgia; Ames, Iowa; Pullman, Washington; and Sturgeon Bay, Wisconsin. Research of the State stations is organized and coordinated through 4 regional projects and 1 inter-regional project: NE-9, Discovery and Preservation of Valuable Plant Germ Plasm; S-9, The Introduction, Multiplication, and Evaluation of New Plants for Industrial and Agricultural Use and the Preservation of Valuable Germ Plasm; NC-7, New Plants - for Industrial and Agricultural Utilization; W-6, The Introduction, Multiplication, Preservation, and Determination of the Value of New Plants for Industrial and Other Purposes; and IR-1, Introduction, Preservation, Classification, Distribution, and Preliminary Evaluation of Wild and Cultivated Species of Solanum. All 50 States and Puerto Rico cooperate in this research. Cooperation between the State stations and the Department in this program is outstanding and of great mutual benefit.

The total research effort on replacement crop introduction and evaluation at the State stations is approximately 60.0 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Plant Introduction

Breeding Stock Introduction. The plant exchange program during the past year resulted in 8,908 introductions from and 1,615 shipments to some 122 countries. This is the greatest number of introductions received since 1953, excepting 1957. Vegetable introductions numbered 1450.

International Exchange. Special note is made of the exchange with the U.S.S.R. and satellite countries which provided a total of 2,026 introductions. Latin America supplied 224 vegetable lines.

Domestic Exploration. A survey of low-temperature tolerant vegetable varieties was undertaken by the Rhode Island AES as part of regional project NE-9.

Maintenance of Germ Plasm. Good progress has been made in depositing germ plasm in the National Seed Storage Laboratory, Fort Collins, Colorado. Seven thousand items were added, bringing the total in preservation to 29,000 lines.

Studies on retention of viability of seeds of lettuce, safflower, sesame, crimson clover, and sorghum in sealed containers showed that at temperatures below 50° F. high viability was retained for 36 months even at moisture contents up to 10%. When these same crops were stored in sealed containers at 4% moisture, viability was maintained for 36 months throughout a temperature range of 10° to 90° F.

B. New Crop Evaluation

Waterchestnut research at Savannah resulted in determination of seed treatments essential to germination. Soaking for 90 minutes in 96.2% H₂SO₄ ruptures the bony endocarp and permits germination. Currently, all waterchestnut research is based on vegetatively produced stocks. Seedling population research will afford the possibility of determining genetic variability in the waterchestnut. Preliminary fertilizer trials with phosphorous indicate increased yields of market quality corms with applications of up to 66 pounds of phosphorous per acre. Two hundred and thirty-three pounds of propagating corms of waterchestnut were distributed to growers wishing to cultivate this new crop.

Regional Cooperative Research Programs. Highlights of findings resulting from the expanding use of plant introductions, especially as sources of disease resistance, are as follows:

Allium cepa, P.I. 249903 (Spain), and A. fistulosum, P.I. 274254 (Japan), have shown resistance to pink root rot (NC-7). Cucumis sp., P.I. 164797 (India) is resistant to angular leaf spot (NC-7) and Cucumis sativus, P.I. 164756 (India), is resistant to powdery and downy mildew and fruit rot (S-9). A pepper introduction, P.I. 264281 (Florida), is resistant to two strains of potato Y virus (S-9) and the newly-released lettuce, "Valmaine," grown in Texas, owes mildew resistance to P.I. 167150 (Turkey) and mosaic tolerance to P.I. 120965 (Turkey) (S-9).

The curly-top resistant tomato, "Payette," owes its disease resistance to Lycopersicon hirsutum, P.I. 126936 (Peru) (W-6), and a selection of L. pimpinellifolium, P.I. 127805 (Peru), has shown resistance to bacterial wilt in Hawaii through 9 generations (W-6). A carrot introduction, P.I. 225868 (Denmark), carries resistance to Alternaria, Cercospora, and Aster Yellows, and P.I. 226043 (Japan) also carries Aster Yellows resistance (Beltsville).

Introductions which have contributed horticultural characters are as follows: P.I. 263058 and P.I. 263060 (USSR) are high quality cabbage varieties. The former is a late-maturing type highly suited for kraut, while the latter is early, crisp, of good flavor, and develops medium size heads (W-6). Two broadbeans, P.I. 223302 (Afghanistan), and P.I. 244345 (Ethiopia), are acceptable for freezing types (W-6) and a large-seeded white bean "Blance Alubia de Asturia," P.I. 226856 (Spain), is of considerable commercial interest (NE-9).

The "Summer Tomato" developed by Texas AES has P.I. 190256 (New Caledonia) as a parent. This new release sets well in warm weather and is resistant to cracking, puffing, catfacing, and blossom-end rot (S-9).

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

- Bass, L.N., D.C. Clark, and E. James. 1962. Vacuum and Inert-gas Storage of Lettuce Seed. AOSA Proceedings, Vol. 52: 116-122.
- Sowell, Grover, Jr., and W. R. Langford. 1963. Evaluation of introduced peppers for resistance to bacterial spot. Proc. A.S.H.S. 83: 609-612.
- Winters, H. F. 1963. Ceylon spinach (*Basella rubra*). Economic Botany 17(3): 195-199.

SWEETPOTATO CULTURE, BREEDING
DISEASES, AND VARIETY EVALUATION
Crops Research Division, ARS

Problem. Acreage and per capita consumption of sweetpotatoes have declined for many years. Production and handling of the crop require much labor. Because the sweetpotato crop has not been adequately mechanized, sweetpotatoes are becoming increasingly a luxury item on the market. Yields per acre remain relatively low. Losses from diseases, including those caused by viruses, are high, and controls to date have not been generally applied effectively. Volume of processed sweetpotatoes is far below that of white potatoes although about one-third of the crop is processed. Further decline in consumption per capita has been retarded by the moderate trend toward processed products for which mechanization has been successful in lowering the per-unit costs of production. New disease-resistant varieties of sweetpotatoes of high quality and suitability for processing, especially canning, and additional research on the nature and control of diseases are essential.

USDA AND COOPERATIVE PROGRAM

The breeding program, utilizing selected parent stocks, has been continued at Beltsville in the search for better disease-resistant types suited to fresh market and processing requirements. The inherent and performance characteristics considered in the program are root shape and uniformity, appearance, size, set, skin and flesh colors, overall yielding capacity, and yields of desired grade classes for specific end uses, baking and processing quality properties, storability, propagative characteristics, general plant vigor and growth habits, and adaptability to mechanized culture and handling procedures. Special attention is given to the development of selections possessing multiple-disease and pest-resistance. Investigators in 20 States cooperate in the sweetpotato improvement program. Coordination of the overall cooperative improvement effort is handled at Beltsville, Md. Pathological studies and techniques for eliminating virus infections are conducted at Beltsville.

A program to develop better sweetpotato breeding parent lines is conducted at Tifton, Georgia by Federal workers in cooperation with the Georgia Coastal Plain Experiment Station. Selected materials to be used in this endeavor are being assembled and studied. Underway at this location are cytogenetic studies of Ipomoea species closely related to sweetpotatoes, intended to furnish a sound basis for subsequent basic studies on the genetics of the sweetpotato.

The Federal effort devoted to research in this area totals 4.9 professional man-years annually. Of this total 3.6 is devoted to breeding; 1.1 to diseases; 0.1 to variety evaluation; and 0.1 to culture.

PROGRAM OF STATE EXPERIMENT STATIONS

There is little cultural research directed specifically to the sweetpotato. There are numerous more general projects on the culture of vegetable crops, and work on sweetpotatoes is to be found under these when the occasion warrants such research. Cultural research with sweetpotatoes is concerned with fertilization, planting and harvesting dates, plant bed preparation, and weed control.

Nine States mainly in the Southeast have projects dealing with the breeding or variety evaluation of sweetpotatoes. Sweetpotato breeding is designed to develop varieties having superior yield under local conditions, of high market and nutritive value, possessing good processing characteristics, and resistant to diseases. Both fresh market and processed quality is determined by chemical techniques and taste panel scores. The breeding work is supplemented with research on genetics and cytogenetics.

Research on diseases of sweetpotatoes is pursued intensively through a well coordinated program at the State stations. Four research projects are directed toward providing knowledge essential to control of Fusarium oxysporum batatis. New insight into its variability and pathogenicity is also being obtained through one research project. Research is in progress on strains of the internal cork virus, blister disease, russet crack, on heat treatments for control of scurf, and chemical treatments for root rot, stem rot, and surface rot.

The total research effort on sweetpotatoes at 12 States is approximately 14.3 professional man-years, of which 0.9 is for culture, 12.4 for breeding and varieties, and 1.0 for disease investigations.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Breeding

1. Hybridization and Seed Production. Twenty-six selected parents were used in 132 cross combinations in the breeding program at Beltsville in 1963. About 2200 seeds were harvested from the controlled crosses, along with about 2300 additional seeds, resulting from open pollinations of desirable seed parent stocks. Of 20 parent stocks being used in the 1963-64 season 15 have low darkening-potential properties in addition to other desirable characteristics. One parent line, B6847, appears to be immune from the internal cork virus.

2. First-year Seedling Evaluations. On the basis of appearance and general field performance 116 out of 583 seedlings were retained at harvest. Forty-one of these were saved for future tests, following baking quality evaluations and storage behavior ratings. Fusarium wilt resistance exists in 15 of these 41 selections.

3. Breeding Parent Development; Genetic and Cytogenetic Studies. An isolation plot for maintenance of sweetpotato breeding stocks in a disease-free condition is being developed at Alapaha, Georgia. Selection of basic parental stocks has been initiated in two ways: (1) Assembling of sweetpotato selections of known reaction to various diseases and insect pests. Fourteen stocks are already at Tifton, Ga. Additional materials are being screened and rendered free of virus disease infection at Beltsville; (2) Selection from existing breeding lines of plants exhibiting abundant flowering, good seed set, and meiotic regularity, and evaluation of their reactions to diseases and pests. Some controlled crossing has been done between selected parent stocks for genetic studies.

Cytogenetic studies are essential to basic studies of the modes of qualitative and quantitative inheritance. The sweetpotato is a hexaploid and difficult to work with. Studies have been conducted with a number of related Ipomoea species having lower ploidy levels. A collection of 55 Ipomoea species has been assembled at Tifton, Ga. Chromosome numbers have been determined for 14 of these, and some interspecific crosses have been made successfully.

B. Diseases

1. Fusarium Wilt. A total of 117 seedlings out of 475 were rated moderately to highly resistant to the 5-wilt strains employed in the 1963 tests. These results show that resistance to wilt had been incorporated into almost 25 percent of the tested lots developed in the preceding year's breeding program.
2. Black Rot. Tests of 29 selections for resistance to the black rot disease, involving inoculations with 3 different cultures of the organism indicate that the most resistant selections were V2158, B7360, and P.I.277636.
3. Internal Cork. Studies on varietal susceptibility to the internal cork disease have indicated that the presence of the leafspot virus component of the internal cork syndrome interferes with and even prevents the root lesion expression of internal cork in some of the varieties tested. Variation in susceptibility to internal cork within a variety can be ascribed largely to the presence of variable amounts of the leafspot virus component.
4. Tobacco Ringspot. Tobacco ringspot was isolated recently from one lot of Georgia Red sweetpotatoes.
5. Yellow Dwarf. Graft inoculations for two years in succession were necessary in order to produce distinctive symptoms of yellow dwarf component of feathery mottle.

6. Russet Crack. Typical symptoms of this trouble have persisted since 1961 in Jersey type sweetpotatoes produced at Beltsville. All attempts to establish a causal relationship with the *Rhizoctonia* fungus which was frequently isolated from Russet Crack-infected roots, have been unsuccessful.

7. Heat Treatments of Whole Plants for Virus Control. Continuous exposure for 3 months at approximately 38° C. proved ineffective. Similar exposure for 6-month periods in a series of experiments resulted in apparent elimination of the virus from variable percentages of mother plants. The exact manner in which the mother plants were freed of virus was not determined. There was evidence of differences in varietal resistance to the elimination process; Heartogold plants, for example, appeared virus-free after 5 months' heat treatment in all but the last of the experiments referred to above, whereas 4 Porto Rico selections all remained viruliferous at the end of 6 months' treatment.

C. Variety and Selection Evaluation

1. Regional Testing of Advanced Selections. Eighteen advanced selections were tested at Beltsville and at 24 cooperating State testing locations. Yield depression because of drought was especially noticeable and consistent in Copperskin, Goldrush, and 5 numbered selections. NC-188, the highest yielder, had 74 percent of its total yield in the "cracked" root category.

Samples of canning size roots of Regional selections were processed and detailed objective canning quality evaluations are being made through cooperation of the Horticultural Crops Branch, Agricultural Marketing Service.

2. Testing of Advanced Beltsville Selections. Eleven out of 25 advanced Beltsville seedlings compared in replicated field plantings were discarded because of their tendencies toward cracking and roughness under adverse growing conditions. Roots of seven advanced "B" selections, producing high yields of canning size stock, were canned, after curing and one month of storage, through cooperation of the Horticultural Crops Branch, Agricultural Marketing Service. When canned samples were examined three months later, those of B7078, B7162, and B7340 appeared acceptable on the basis of firmness, color, and flavor characteristics.

3. Enzymatic Darkening Ratings. Readings were made of the degrees of enzymatic darkening for all selections in the Regional Trials and in 15 advanced Beltsville seedling lots. Remarkably little darkening was found in roots of the Beltsville seedlings 7340, 7341, 7353, and 7377, and in L-9-5-6, L-9-89, and E-1097-57 among Regional Observational lots.

4. Introduction. Two new introductions from Spain and four from Taiwan, supplied through cooperation of the New Crops Research Branch, were observed in 1963 field plantings at Beltsville along with 22 stocks introduced in other years. Selections D49, D50, and the two Spanish selections have been freed from virus and sent to Tifton for genetic and parental line development work. Plants of several earlier introductions are being freed from virus for shipment to Tifton, Georgia.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Breeding, Genetics, and Variety Evaluation

Hughes, M. B., C. E. Steinbauer, M. T. Deonier, and H. B. Cordner. 1963. Preliminary studies on the inheritance of wilt resistance in the sweetpotato. Amer. Soc. Hort. Sci. Proc. 83:623-628.

Diseases

Hildebrand, E. M., and Charles Drechsler. 1963. An unusual root injury on Jersey-type sweetpotatoes in 1962. Plant Disease Reprtr. 47(6):562-563.
Hildebrand, E. M. 1964. Heat treatment for eliminating internal cork viruses from sweetpotato plants. Plant Disease Reprtr. 48:356-358.

ONION, CARROT, AND OTHER ROOT AND BULB CROP CULTURE,
BREEDING, DISEASES, AND VARIETY EVALUATION
Crops Research Division, ARS

Problem. The production of onions, carrots, garlic, shallots, and related crops is fairly well stabilized to adapted and highly specialized areas. Cultural requirements, methods, and practices vary widely from one location to another. There is need to develop improvements in methods of growing the crops. The superiority of onion hybrids has been demonstrated, but methods of hybrid seed production need much further work. Principles of hybrid carrot seed production need yet to be worked out. Further breeding is necessary to incorporate disease and insect resistance into varieties suitable for home and commercial production. The generally rather narrow environmental adaptation of most varieties limits them to specific production areas, necessitating development of many regionally adapted varieties. Increased research is needed on the genetics of all these crops to facilitate improvement of varieties and hybrids.

USDA AND COOPERATIVE PROGRAM

The Department research in this area is long term and continuing. The primary objectives are to develop new and improved breeding lines, varieties and hybrids of carrots and of onions that are disease and insect resistant, high yielding, more uniform, and adapted for special uses. This work is being done by Federal personnel at Beltsville, Maryland; Greeley, Colorado; and Parma, Idaho. The Station at Parma also develops information on cytology, genetics, and problems relating to seed production. Development of breeding lines with genetic resistance to diseases is a major objective at Beltsville and is done cooperatively with many State experiment stations and private seed and food-processing companies. Germ plasm from species related to Allium cepa is being utilized in efforts to improve the commercial onion. Breeding of onions and carrots, including work on development and improvement of hybrids, using cytoplasmic male sterility, is done cooperatively at Madison, Wisconsin; Davis, California; Logan, Utah; Ithaca, New York; and Ames, Iowa. Studies of the nature and control of diseases of carrots are conducted at Weslaco, Texas, and research on onion diseases is being done through informal cooperation with several State and private agencies.

Two 5-year PL 480 projects are currently in effect: (1) Studies on the Epidemiology of Onion Downy Mildew, Peronospora destructor, with the Institute of Soil Science and Cultivation, Skierniewice, Poland; (2) Study of the Causes of Root Greening in Carrots, Institute of Plant Breeding, Wrzblewskiego, Cracow, Poland. These projects amount to \$81,947.29 in Polish zlotys.

The Federal scientific effort devoted to research in this area totals 3.6 professional man-years, divided as follows: 3.1 breeding and genetics; 0.5 diseases.

PROGRAM OF STATE EXPERIMENT STATIONS

Cultural research is done on onions, carrots, and other root and bulb crops by State agricultural experiment stations. Only three projects are noted which are specific for cultural research on onions, carrots, and other root crops. Two of these, in New York, are on management of muck soils for vegetables; one is in Texas on fertilization, irrigation, and cultural practices for onions and carrots.

Fourteen projects in nine States are involved with the breeding or variety testing of root and bulb crops, mostly on onions and carrots. The objectives and methods are similar to those of USDA work and most of it is cooperative and coordinated with USDA work. State work is also done on improving turnips and table beets.

Research on diseases of onions, carrots, and similar crops is pursued at several of the State institutions. A number of diseases such as those caused by Pyrenochaeta, Botrytis, and Sclerotium are being investigated. Investigations on the cellulolytic and pectolytic enzymes involved in fleck and blight disease of onions is done in one of these projects. Taxonomic studies in the genus Botrytis, and the relation of the two species on onion is being pursued, along with studies on sclerotial formation in the onion pathogen, S. cepivorum. Resistance to pink root and yellow dwarf is being developed in shallots. Fumigants in onions are being studied. The role of fungistasis and lysis in soilborne diseases is also being investigated. Portions of this research is coordinated through a regional research project on some of the mechanisms involved in soilborne disease.

The total research effort on onions, carrots, and other root and bulb crops at the State stations is approximately 6.6 professional man-years, of which 0.6 is for culture, 5.2 for breeding and variety evaluation, and 0.8 for disease investigations.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Breeding

1. Short-day onions. A pink-root-resistant TEG 951 C with sufficient depth to produce a good F₁ hybrid Granex has been selected for increase and evaluation for combining ability. Other characters which are being incorporated into the short-day onions are powdery mildew resistance, Botrytis resistance, and resistance to premature bolting.

2. Long-day onions. The F₁ hybrid onion Chieftain (U 16-3-11 x B 12115-2) was introduced with the Idaho and Utah Agricultural Experiment Stations in April 1963. U 16-3-11 is heterozygous for resistance to pink root in Oregon and Texas. The hybrid was one of the best appearing and highest yielding at Greeley, Colorado, in 1963. It can be grown in areas where Yellow Sweet Spanish is adapted.

The F_1 hybrid onion El Capitan was released with the Idaho Agricultural Experiment Station. The inbreds P 52-371 and P 54-306 are derivatives of Yellow Sweet Spanish and both are heterozygous for pink root resistance in Oregon and Texas. A and B lines of both inbreds are available so either inbred can be used as the pollen parent in the F_1 hybrid. Higher yields are obtained with the Spanish x Spanish cross than with the Yellow Globe x Spanish cross; however, losses in storage are usually greater.

3. Thrips resistance. Four inbreds from crosses between *A. cepa* and *A. fistulosum* and six inbreds from crosses with *A. cepa* (using PI 86270 White Persian as one parent) showed thrips resistance. Three of the 10 inbreds are homozygous for nonglossy leaves. One inbred, B 3343, is heterozygous for the glossy foliage, is highly thrips resistant, and resistant to the pink root fungus in Texas and Oregon.

4. Species crosses. The species cross, *A. cepa* x *A. fistulosum* and the reciprocal cross, indicate that *A. fistulosum* possesses the same gene for male sterility and possibly is the source of the original sterile type cytoplasm found in Italian Red 13-53.

5. Genetic studies. Brown seed coat color in onion is controlled by at least one single gene pair and is recessive. Associated with the brown seed coat color is the character for round seed. No linkage between gene for brown seed coat and other characters other than round seed has been found.

The variabilities of six bulb traits--weight, height, diameter, height/diameter x 100, number of scales and average thickness of scales were measured and analyzed. For every trait the mean of the F_1 was intermediate between the parental means. The variations in size (weight, height, and diameter) of bulbs within lots are positively correlated with variations both in number and in thickness of scales. Among the lines studied the "flat" lines had thicker, but fewer scales, and the "tall" lines, thinner but more scales within any given size class. Apparently little progress can be made by selecting inbreds deliberately for either more scales or thicker scales. Scale thickness might affect firmness and storage ability, however.

6. Carrots

Several F_2 families of the cross French Forcing (short round roots) by long slender varieties were measured to investigate the inheritance of root shape in carrots. In general, the F_1 hybrid was intermediate between the two parents.

Specific gravity of carrot roots varies greatly among varieties as well as within varieties, e.g., Long Chantenay 1.031; Royal Chantenay .998; Red Core Chantenay #5, 1.010; Empress 1.026; Nantes 1.021; Danvers 126, 1.009.

The variation within the Danvers 126 strain was from .969 to 1.032. The highest specific gravity root was found in Long Chantenay and the lowest in Amsterdam Forcing. Low specific gravity causes difficulty in meeting drained weight requirement in the canned product.

A petaloid type of male sterility has been found in a wild carrot PI 279767 from Sweden. The anther or pollen-degeneration type of sterility has been found in several of the carrot introductions as well as in domestic varieties.

B. Diseases

1. Mildew

A. tuberosum, PI 255461 S₁ and Calred showed resistance to downy mildew in Poland. The latter two had previously been selected for resistance in California. The inbred P 54-306 and PI 249903 show resistance to mildew and also to pink root in Oregon and Texas.

2. Pink root.

The inbreds Co 7-13-4, U 16-3-10-2, Ia 13, Ia 1408, Ia 2578, Ia 2997, and Ia 3190 have shown resistance for pink root in Oregon and Texas. Many other inbreds are heterozygous for resistance. Most of the USDA-released inbreds are susceptible to pink root with the notable exception of B 2264 and B 2190. The inbreds P 54-306, P 52-372, U 16-3-10-2, U 16-3-11 and B 12132 are heterozygous for resistance. Lines resistant to pink root in Texas are not necessarily resistant to pink root in Oregon. Apparently two or more genes are necessary for resistance in both areas.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

None.

PEAS AND BEAN CULTURE, BREEDING,
DISEASES, AND VARIETY EVALUATION
Crops Research Division, ARS

Problem. The present major obstacle to economic production of beans and peas is diseases. Aside from disease control, the greatest need is new, more productive, widely adapted, high-quality, disease-resistant varieties. Biological controls of pests and diseases through breeding and other means are preferred to chemical methods when feasible. There is need to develop cultural, genetic, and pathologic information on "southern peas," dry peas, and lentils.

USDA AND COOPERATIVE PROGRAM

At Beltsville, Maryland, studies are conducted on breeding techniques and on the inheritance of specific economic characters, especially resistance to certain diseases of snap beans and lima beans. Outlying evaluation of breeding materials is managed from here.

At Twin Falls, Idaho, and at Prosser, Washington, (cooperative with the Idaho and Washington Agricultural Experiment Stations) applied breeding is conducted on dry beans for the West and on snap bean varieties grown both for food and seed purposes in the West. Resistance to beet curly top virus is a major objective. Breeding disease resistant peas is conducted at Prosser and on southern peas at Tifton, Georgia (cooperative with the Georgial Coastal Plain Experiment Station). Emphasis on peas is on the genetics and development of disease resistant stocks for variety synthesis by others. At Pullman, Washington, work is conducted on the development of superior lentil and dry pea varieties (cooperative with the Washington Agricultural Experiment Stations).

At East Lansing, Michigan, (cooperative with the Michigan Agricultural Experiment Station) a well-rounded program of breeding and selection of disease resistant dry beans is conducted for the humid dry bean districts of the United States, chiefly Michigan and New York.

At Charleston, South Carolina, disease resistant snap beans are bred for adaptability to the Southeast for market and processing.

At Beltsville, Maryland, conventional pathologic studies on certain virus, fungus, and bacterial diseases and development of control measures are conducted on snap, dry, and lima beans, and peas. Similar studies on dry beans are conducted at East Lansing, Michigan, and on virus diseases of peas in the Northwest at Corvallis, Oregon (cooperative with the Oregon Agricultural

Experiment Station). Work, mainly on fungus diseases of peas, is conducted at Prosser, Washington, and diseases of southern peas at Tifton, Georgia. At Prosser, special attention is given to control of root rot of beans through microbiological means in the soil. Diseases of dry peas and lentils are investigated at Pullman, Washington.

At University Park, Pa., epidemiology research was continued on downy mildew of lima beans.

The Federal scientific effort devoted to research in this area totals 11.2 professional man-years. Of this number, 5.4 are devoted to breeding and genetics, 5.5 to disease, 0.1 to variety evaluation, 0.2 to culture.

PROGRAM OF STATE EXPERIMENT STATIONS

There are 60 general projects on the culture of vegetable crops on record from 33 States. Cultural research on peas and beans is done under some of these projects when the need arises. There are 9 projects in 5 States specifically on the culture of peas and beans. These investigations include nutritional studies on southern peas and snap and dry beans, quality in lima beans, tillage of dry beans, and flower and pod drop in lima beans.

Forty-six projects in 21 States involve breeding or variety testing of snap, field, and lima beans, peas, and southern peas for development of varieties of local adaptation, disease resistance, and greater consumer quality. Considerable emphasis is placed on developing southern peas and snap beans that are adapted to mechanical harvesting. The breeding programs are supplemented with genetic and cytogenetic studies.

Fusarium root rot is being studied through a well coordinated regional research project. The nature of resistance, mechanisms of pathogenesis, amino acid metabolism of the fungus, variability in virulence and its cause are some areas under investigation. Interesting new relationships between a fungus and a virus are being studied. The genetic basis for resistance to bean yellow mosaic virus, root rot, and anthracnose are being studied. Studies on cowpea chlorotic mottle virus are being conducted. Root tip inoculation techniques have been conducted on the Aphanomyces disease in peas. Nematode problems in peas are being investigated. Chemical treatments for the control of lima bean root rot and anthracnose also are underway. Root and foliar feeding techniques are under study to control root rot.

The total research effort on peas and beans at the State stations is approximately 25.9 professional man-years, of which 2.4 is for culture, 15.2 for breeding and variety evaluation, and 8.3 for disease investigations.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Breeding1. Dry Beans

a. Three early maturing, mosaic-anthracnose resistant bush type pea beans, superior to Seaway in disease resistance, canning quality, and yield were increased preparatory to release.

b. Fusarium resistant lines. In Michigan several hundred individuals were tested for Fusarium root rot resistance. Those with the greatest tolerance were intercrossed to maintain resistance and backcrossed to mosaic-anthracnose resistant beans.

In Washington breeding of dry beans resistant to fusarium root rot received major emphasis. A new method was developed for uniform field testing of beans in soil naturally infested by root rot pathogens. About 400 root rot-tolerant selections were made, many of which have seeds equal to commercial types.

c. Curly top and mosaic resistance. In Washington, in the development of high yielding, dry bean types with strong bush growth habit adaptable to improved harvesting methods, selections with improved non-fading seed color were made among early Pintos. Nine advanced early Red Mexican lines outyielded commercial Red Mexican varieties on land free of root rot, but not on land where root rot was severe. Semifinal selections were made among 90 advanced curly top resistant Red Kidney lines.

2. Snap Beans

a. New releases and superior selections. Bean line D-11, a curly top and mosaic resistant green podded snap bean was released to seed producers.

b. Advanced breeding lines. A quality-yield study of the best curly top-resistant snap beans indicated D-9 has possibilities for freezing. From 76 secondary elite lines evaluated at Twin Falls and Prosser, 17 singles and 11 bulks were retained for retesting, 12 lines were shelved, and the others discarded. From 10 wax elite lines and 320 selections, 2 bulks and 22 single plant selections were retained. Most wax lines were late in maturity and yielded poorly in the Midwest and East. A white seeded diethyl sulfate-induced mutant from the D-7 increase appeared to be a true mutant.

c. Rust resistance. In the development of rust resistance in snap beans several resistant selections, both flat and round podded types from F₃ and F₄ backcross populations were made at Salisbury, Md. Additional backcrosses were made in the greenhouse to incorporate this resistance into six popular bean varieties.

d. Early generation multiple disease resistance. A test method for field tolerance to fusarium root rot was developed and 19 single plant selections were chosen in developing snap bean types having some root rot tolerance. Screening of commercial varieties and P.I. materials for virus resistance has produced some selections with a high degree of tolerance to several important bean viruses. Study of the inheritance of resistance to these has been initiated.

e. Anthrachnose resistance. Breeding to develop anthracnose resistant snap beans was started at Beltsville; the initial crosses were made.

3. Snap Beans for the Southeast

a. Quality studies. Paper chromatograms of extracts from seedlings of six bean varieties indicated differences among varieties in quantities and kinds of flavonoid compounds. Rf values indicate that most spots are flavonoid glycosides. With some exceptions Contender, Black Valentine, and Tendergreen have similar patterns. Blue Lake extracts show a blue fluorescent spot at Rf .37, not present in other varieties. The flavonoids have not been identified.

Eight lines have been selected for improved pod structure. Forty-seven families have been developed with strong viable seed and low seedcoat rupture, two of which appear to be phenotypically uniform for this character; the history of these extends 27 and 29 generations from the original crosses.

b. New crosses and selections. About 100 crosses were made in the greenhouse. Selection has been made for stronger bushes, initial vigor, moderate height, and early extensive branching. The strongest bush type that is now in the program is a new white seeded line, B3780, that originated from a cross which included Blue Lake and Phaseolus coccineus as parents backcrossed to several bush type hybrids. The variety Wade is an excellent parent in crosses where increased yield is desired.

4. Lima Beans

a. Downy mildew. Strain "B" of downy mildew (Phytophthora phaseoli) has not spread from the original area in New Jersey where it was first found in 1958. The occurrence of downy mildew has declined since the introduction of Thaxter, a resistant variety released in 1958, and the use of fungicides.

b. Competitive effect of seed size. Seedling vigor, height and fresh weight of plants and yield were found associated with seed size. Plants from smaller seed yielded considerably more when not crowded by larger plants originating from larger seed. Yields of lima beans probably can be increased if the seed is sized before planting and various seed sizes planted separately.

5. Green Peas (Processing Types)

About 800 lines (commercial and P.I. material) were evaluated for disease resistance and horticultural characteristics. About 225 F_1 hybrids were increased, and 70 were backcrossed. Breeding for root rot resistance using P.I. 140165 has produced some definite tolerance in severe greenhouse bench tests. The nature of this tolerance is unknown.

6. Cowpeas

Twenty-one new varieties and breeding lines were evaluated for resistance to Cercospora leaf spot, powdery mildew, Cladosporium leaf spot, cowpea rust, and southern bean mosaic virus. In conjunction with the Southern Cooperative Vegetable Variety Trials the cowpea variety trial and the breeding line observation test were grown and evaluated in 1963 at Tifton, Ga. Crosses were made in the study of the inheritance of resistance to a virus and a fungus disease.

7. Dry Peas and Lentils

Thirty-five commercial lines of Alaska type peas were compared and three were found superior in vine type to the types currently grown in the Palouse region. In 1964 yield tests are planned for six of these lines. Sixty-one P.I. lines were grown and 14 were selected for further testing.

Twenty-eight lentil lines were grown in an observation nursery and 1,200 single plant selections were made. In 1964, 254 single plant selections will be tested for vine and seed type.

Experiments demonstrated that environmental factors such as sun and rain induce bleaching in dry peas. Further data showed that varieties differ in the tendency.

B. Diseases

1. Beans and Lima Beans

a. Microbiological control of bean diseases. In Michigan microfloral data obtained by the plate-profile technique was less variable than data obtained from plate dilutions, and could be statistically analyzed without prior transformation. A current crop has a tremendous influence on the soil microflora, and this effect is carried over into the early stages of the following crop. The most frequently isolated indigenous soil micro-organisms were Rhizoctonia, Fusarium, Pythium, Mucor, Trichoderma, and bacteria. All were compatible with most of the organisms isolated. All were influenced by cropping sequence except Rhizoctonia. Fusarium can possibly be controlled biologically through parasitism by an Actinomycete, bacterial necrosis, and lysis.

In Washington, preplanting applications of alfalfa and bean straw pellets below the seed furrow or planting beans in high beds to promote aeration of roots reduced fusarium root rot in 3 fields, but increased seed yields only 200 to 300 pounds per acre.

b. Cultural controls. Wide spacing of plants in 36 lines and varieties of beans was more beneficial to individual plant yields in soil infested by root rot pathogens than in noninfested soil.

c. Histochemical studies of enzymes in Fusarium resistant and susceptible plants. Enzyme activity was high around wound and/or fusarium infection sites. Fusarium resistant plants initiated rapid periderm formation with a deposition of material believed to be partially comprised of quinones or phenols because the material coupled with diazo couplers. Periderm formation was erratic and slow and deposition of wound compounds was delayed in susceptible varieties.

d. Bean viruses. Studies on a new strain of bean yellow mosaic virus which is seedborne to a slight degree and which produces an extremely mild mottle on beans, peas, and other legumes are almost completed. An anti-serum for this virus was developed and is being used to study the serological relationships between it and other bean viruses.

In Washington, bean yellow mosaic virus field spread from red clover, its field pattern, and influence on bean seed yield were studied during 1963. Average seed yields per infected plant were approximately 50% those of healthy plants. Infected plants had as many seeds per pod, but only one-half the number of pods per plant. This suggests that the infection and major effect of the virus occurred prior to pod set.

Studies of viruses infectious to beans which occur in forage legumes indicated a high frequency of bean yellow mosaic types which have physical properties markedly different from those of reported strains. Preliminary electron micrographs showed a rod length of 750m μ . Further serological and microscopic examinations of these viruses are being made by Dr. J. Brandes of Germany. These types were found to be transmitted in red clover seed from the Columbia Basin with a frequency of 16%.

e. Phyllosticta leaf spot. Phyllosticta leaf spot caused by Phyllosticta phaseolina was found early in a number of fields in New Jersey, Wisconsin, and New York. Later as the temperatures increased, the plants recovered and the crop losses were negligible.

f. Halo blight. The determination of possible strains of the bean halo blight organism Pseudomonas phaseolicola was studied on differential bean varieties. The isolates used were from diverse geographical areas and the pathogenicity of only one differed slightly from the type strain.

g. Root rot of lima beans. The effect of seed size and seedcoat condition on the pathogenicity of Rhizoctonia solani on lima bean is being studied. Seeds with damaged seedcoats were more susceptible to infection than those with intact seedcoats. Smaller seeds were also more susceptible than larger ones. Seeds which were soaked in a vitamin B-complex solution for 10 minutes prior to inoculation were not as susceptible to injury by Rhizoctonia as their untreated checks.

h. Mycological studies. During the winter and spring of 1961-62 the sexual stage of Colletotrichum truncatum was frequently observed when two isolates of this organism were mated. During the summer of 1962 these isolates lost their ability to produce the sexual stage. Mating and nutritional studies are still being conducted to determine the factors required for the production of the sexual stage.

i. Downy mildew of lima bean. The effect of daily repeated exposures to high temperature on colonization by Phytophthora phaseoli of Fordhook lima beans in controlled environment chambers was studied at University Park, Pennsylvania. Colonization decreased as the daily exposure at 92°F was increased from 4 to 6 hours and the number of exposures was increased from 2 to 6. With a 4-hour exposure colonization decreased as temperature increased from 86°, to 89°, to 92°, to 95°, or as the number of daily exposures increased from 1 to 7. A statistically significant reduction in length of stem lesions in 8 days over the control plants occurred with one exposure to 92° or 95°, two exposures to 89°, or five exposures to 86°. The high temperature exposures were started after the plants were inoculated.

The temperature of lima bean plant stems, outdoors at University Park and exposed to the sun, exceeded the ambient air temperature by as much as 5° to 7°F. As a result a tentative restriction is maintained on the determination of severity values for forecasting purposes. The restriction is that a maximum air temperature exceeding 85° during the day following an infection period (severity value) the night before nullifies that period for forecasting purposes.

2. Peas

a. Root rot studies. Peas grown in naturally Fusarium-infested soil at 50°F. were affected by root rot only one-fifth as much as plants growing in the same soil incubated at 80°F., indicating the desirability of planting and growing peas the earliest possible in the season where fusarium is a limiting factor.

Cotyledon-rotting bacteria and Rhizoctonia solani have been found to occur with significant frequency beneath the seedcoat of Perfection peas from Central Washington.

A three-year survey of fusarium isolates taken from diseased pea roots has indicated that the majority of these isolates do not conform to the accepted characteristics of F. solani f. pisi. Instead, they more broadly fit into the species of Fusarium oxysporum. The most consistently virulent, root rot-inducing isolates were F. oxysporum types.

b. Chemical control. Field evaluations of chemicals as effective means of pea root rot control indicated that coated seeds with a fungicide in the coating at a cost of \$4-6 per acre produced yields almost equalling those resulting from soil-applied fungicides costing as much as \$100 per acre.

c. Virus studies. In the Pacific Northwest 70 field collections of pea viruses were obtained for studies of host range, physical properties, and storage in dry, cold conditions. Reactions of pea streak viruses were determined. Pea enation mosaic virus (PEMV) resistant commercial varieties were grown in the Willamette Valley with success. Interaction, concentration in tissues of different ages, and translocation of pea viruses were studied. Commercial Perfection type peas were evaluated for bean yellow mosaic virus resistance. All P.I. lines have been tested for resistance to P-42 streak virus. By serological and electron microscopic evaluation it was found to be related to red clover vein mosaic virus. The Ouchterlony agar double diffusion test is being tested extensively for a broad range of uses for legume viruses. Antisera to P-42 streak (N.J.), to 331 streak (Oreg.), and to white clover mosaic virus were produced in rabbits. German and Canadian antisera were obtained for comparisons. Pea mosaic and bean yellow mosaic viruses are also being compared.

3. Cowpeas

Powdery mildew and cowpea rust were more severe than in previous years, particularly under the extremely dry conditions of the fall crop in 1963. Studies on the etiology of viruses that attack cowpeas revealed virus infection from sources other than seed decreased from 96% in the coastal plain along the Florida border to 1% in the mountains in North Georgia. Two aphids were found to be the most prevalent insects and potential vectors (*Aphis craccivora* and *Myzus persicae*). Two systemic insecticides gave no significant control of the insect-transmitted viruses.

A new virus disease found in the experimental plantings on the Coastal Plain Experiment Station and later in a commercial field near Moultrie, Georgia, was identified as a legume strain of tobacco mosaic. The disease had not been previously found in the United States.

4. Dry Peas and Lentils

A bacterium causing mild disease symptoms in peas and lentils was isolated. Observations made during surveys showed that this disease was present in all pea seeds tested, despite the regions of the United States in which they were produced. Infection varied from an occasional plant in a field to 100% infection. Stands and expected yields were reduced by this disease. In germination tests, seed harvested from severely infected plants was inferior to that from mildly infected plants. The disease is seedborne. Preliminary studies indicate that peas, lentils, beans, and soybeans can be infected with this bacterium. Apparently, plants can become infected when grown in bacterial-infested soil.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Breeding

- Atkin, John D. and W. J. Zaumeyer. 1964. White Seeded Tendercrop, a new snap bean for canning. Seed World 94(8):16.
 Silbernagel, M. J. 1963. A method of using mycelial, monosporidial isolates of *Tilletia controversia* in pedigreed hybrid crosses. Phytopathology 53:1235-1236.

Diseases

- Burke, Douglas W. 1963. Incidence of viruses infectious to beans in plants of twelve alfalfa varieties. Plant Dis. Repr. 47:845-847.
 Dukes, P. D., S. F. Jenkins, Jr., and R. W. Toler. 1963. A new disease of tobacco in Georgia. Georgia Agricultural Research, Vol. 5, No. 3
 Ford, R. E. 1963. Susceptibility of Perfection-type peas to bean yellow mosaic virus. Plant Dis. Repr. 47:384-389.
 Ford, R. E. and W. A. Haglund. 1963. Botrytis cinerea blight of peas associated with senescent blossoms in northwestern Washington. Plant Dis. Repr. 47:483-485.

- Goth, R. W. 1963. The effect of low temperature on germination of chlamydospores of *Ustilago avenae*. *Phytopathology* 53:357.
- Goth, R. W. and W. J. Zaumeyer. 1963. The occurrence of *Phyllosticta* leaf spot in beans in 1963. *Plant Dis. Reptr.* 47:1079.
- Toler, R. W., S. S. Thompson, and J. M. Barber. 1963. Cowpea (southern pea) diseases in Georgia 1961-1962. *Plant Dis. Reptr.* 47:746-747.
- Zaumeyer, W. J. 1963. Two new strains of alfalfa mosaic virus systemically infectious to bean. *Phytopathology* 53:444-449.
- Zaumeyer, W. J. and R. W. Goth. 1963. Two new types of local lesions produced on beans by the common bean mosaic virus. *Phytopathology* 53:490-491.
- Zaumeyer, W. J. and R. W. Goth. 1963. Red clover necrosis virus, the cause of a streak of peas. *Plant Dis. Reptr.* 47:10-14.

Culture

- Andersen, Axel L., M. W. Adams, and Gerald Whitford. 1963. The Seaway Pea Bean - Development and Characteristics. *Mich. State Univ. Agr. Exp. Sta. Quart. Bull.* 45:548-559.
- Dukes, P. D., S. F. Jenkins, Jr., and R. W. Toler. 1963. An improved inoculation technique for transmission of false broomrape to flue-cured tobacco. *Plant Dis. Reptr.* 47:895-897.
- Wester, R. E. 1963. Artificial light, sphagnum moss, and plastic film for seed germination. *Amer. Hort. Magazine* 42(4):221-225.
- Wester, R. E. 1964. Suburban and Farm Vegetable Gardens. *Home and Garden Bull. No. 9 (Rev.)*, U.S. Department of Agriculture. 46 pp.

Variety Evaluation

- Adams, M. W. and Axel L. Andersen. 1963. Saginaw bean variety yields good in Midwest. *Crops and Soils* 15:22-23.

TOMATO, PEPPER, AND RELATED CROP CULTURE,
BREEDING AND GENETICS, DISEASES, AND VARIETY EVALUATION
Crops Research Division, ARS

Problem. High costs of harvesting by hand are forcing a revolution in methods of growing and harvesting tomatoes by machine and in types and properties of tomatoes adaptable to such methods, especially for processing. Thus, the tomato breeder has additional difficult objectives to meet, regarding growth and fruiting habits, and fruit properties. The old problems of improving yield, developing resistance to a multiplicity of diseases, including curly top, and improved fruit quality for fresh use and processing are still with us. There are new pressures from large processors to conduct basic work as a basis for improving numbers and quality of plants from southern plant beds and reducing their cost for shipment northward. Bacterial spot is an increasingly frequent cause of trouble. Losses from verticillium wilt and "southern blight" are less tolerable than in the past. The consuming public is becoming more dissatisfied with the poor quality of tomatoes harvested green-mature. Firmer fruits are needed that can be harvested riper than is feasible with present varieties for distant markets. Seed dormancy may interfere with stands.

Disease and productivity problems of peppers are similar to those of tomatoes but the quality problems at present are generally less troublesome.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving geneticists, plant pathologists, and horticulturists engaged in both basic studies and the application of known principles to growers' problems. Tomato breeding and genetic studies at Beltsville, Maryland, involve crossing progeny selection, disease evaluation, and horticultural selection for mechanical harvesting and superior quality. At Charleston, South Carolina, breeding for adaptability to southeastern conditions is stressed; while at Logan, Utah, the prime purpose is development of genetic resistance to the curly top disease. At Woodward, Oklahoma, and Cheyenne, Wyoming, breeding is directed toward adaptability to the temperature extremes and low humidity of the Great Plains. Disease studies on early blight, bacterial spot, gray leaf spot, fusarium wilt, verticillium wilt, and tobacco mosaic virus are conducted in controlled laboratory and field experiments at Beltsville. Disease research at Tifton, Georgia, includes bacterial spot, early blight, gray leaf spot, and southern blight of tomato, pepper, and similar vegetable transplants. At Prosser, Washington, work is concentrated upon identities and variation in strains of the curly top virus. Limited varietal evaluation is conducted at Beltsville, Maryland; Tifton, Georgia; Logan, Utah; and

Prosser, Washington. Work on culture and nutrition of tomato and pepper plants is conducted at Tifton, Georgia.

Epidemiological research was continued on bacterial spot of pepper and tomato in cooperation with Pennsylvania Experiment Station.

The Federal scientific effort devoted to research in this area totals 7.3 professional man-years. Of this number 3.3 are devoted to breeding; 3.0 to diseases; 0.3 to variety evaluation; 0.7 to culture.

PROGRAM OF STATE EXPERIMENT STATIONS

There are 60 general projects on the culture of vegetable crops on record from 33 States. Cultural research on tomatoes, peppers, and related crops is done under some of these projects when the need arises. Dealing specifically with the culture of tomatoes, peppers, and related crops are 22 projects in 12 States. The bulk of these projects are concerned with tomatoes. Research includes studies of the nutritional requirements of both field grown and greenhouse tomatoes, effect of growth regulators on fruit set, influence of light intensity and temperature on development of greenhouse tomatoes, cultural requirements of tomatoes in plastic houses, effect of supplemental CO₂ in greenhouse production, plant growing methods, and studies of the physiology of ripening of the tomato. Research with peppers includes studies of spacing and fertilizer requirements for Bell and Pimiento peppers and pepper plant growing methods.

Tomato and pepper breeding is in progress under 42 projects in 29 States. Tomato breeding is concerned with both fresh market and processing types. Currently considerable emphasis is placed on developing processing tomatoes adapted to mechanical harvesting. Disease and nematode resistance is emphasized along with quality for either fresh market or processing. Various types of peppers are receiving breeding attention including sweet, pungent, pimiento, and chile. Considerable fundamental genetic research is done employing the tomato as a tool. Breeding of tomatoes throughout much of the country is coordinated through the STEP trials of the Southern States and USDA.

Genetic research is coordinated through the activities of the Tomato Genetics Cooperative.

Scientists at the State stations are providing leadership through a number of research projects on the diseases of tomato, and related crops. In some cases these involve fundamental studies on viruses, such as synthesis, multiplication, mode of action, and the biochemical specifics of resistance. Others are concerned with nuclear phenomenon and nucleic acid synthesis in selected tomato pathogens such as the early blight organisms. Work on bacterial agents of pepper and tomato

diseases, such as P. solanacearum is providing new concepts of value in control of many bacteria, as well as providing new findings on strains affecting tomato that can be serologically and biochemically defined. Research on the use of viruses (phages) to establish strain and pathogenicity patents is of much value. New types of genetic resistance to virus and nematodes in pepper offer great promise. Radiological techniques are being used to isolate efficient sources of mosaic resistance. Leaf spot and blotchy disease resistance has been located through careful investigations, and the ability to differentiate mosaic strains for use in breeding studies are valuable contributions. Bacterial spot of pepper, and seed borne bacterial diseases of tomato are receiving special attention. Refined and efficient chemical controls for pepper and tomato diseases are being developed through research at some locations.

The total research effort on tomatoes, peppers, and related crops at the State stations is approximately 45.3 professional man-years of which 9.6 is for culture, 26.0 for breeding and variety evaluation, and 11.7 for disease investigations.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Breeding

1. Tomatoes

a. Selection for fruit quality characteristics from multiple disease resistant germplasm. Special attention is given to quality as well as disease resistance. Low pH, high solids, intense exterior and interior color, good flavor, firmness and crack resistance are highly desirable. Among several hundred firm-fruited crack-resistant selections, pH ranged from 3.9 to 4.8, soluble solids varied from 3.7 to 7.7, interior color of many selections was rated excellent.

Cooperative studies on evaluating breeding lines for processing quality and flavor characteristics were initiated with the Agricultural Marketing Service and Food Quality Laboratory, ARS, respectively.

b. Varietal and regional observational trials. B-96, an early determinate multiple disease-resistant crack-resistant tomato line proved widely adapted in the STEP trials and at Beltsville in 1963. Two mid-season, productive, high quality lines grown in New Jersey in 1963 were selected for commercial grower trials in 1964. Fourteen machine harvestable paste lines resistant to verticillium and fusarium wilts are included in trials at Beltsville, Maryland, Bridgeton, New Jersey, and Fort Lupton, Colorado, in 1964. Two paste lines are being grown in a number of grower trials over the United States in 1964. Four determinate, multiple disease resistant tomato lines were entered in the STEP trials in 1964.

c. Breeding for resistance to tobacco mosaic virus in tomato. Five apparently true-breeding TMV resistant lines were selected in 1963. Second generation inbreds from these lines remained free of TMV 30 days after multiple virus inoculation.

d. Breeding tomatoes for the High Plains. At Cheyenne, Wyoming, approximately 300 promising individual plant selections were made possessing compact vines, ability to set under low night temperature, earliness, excellent yields of medium to large fruit, low fruit pH, high soluble solids, firmness, meatiness, crack resistance and excellent interior and exterior color. Advanced line 6225 and 6 paste type lines were selected for grower trials at Fort Lupton, Colorado.

e. Verticillium and fusarium. At Logan, Utah, ten wilt resistant lines were selected from 121 entries for further trials in 1964. Four lines were grown in isolated seed increase blocks for grower trials in 1964.

f. Breeding systems at the Vegetable Breeding Laboratory, Charleston, South Carolina. Studies to evaluate different systems of breeding were continued. A program of enforced sib-crossing was advanced two generations in 29 lines along with their continuously selfed counterparts. Many of these lines are approaching the stage where performance tests can be made and evaluated in relation to the systems used in their breeding.

g. Inbreeding depression. In order to test the common belief that tomatoes do not show inbreeding depression, a study was started on seed vitality of selfed versus sib-crossed seed.

h. Advanced line performance. Three VBL lines - STEP 372, 373, 397, were advanced to the replicated STEP trials in 1963. STEP 373 and 397 were selected for repetition in the 1964 yield trials. STEP 397 was accorded "Best" rating among all entries in the replicated trials at six of the thirty locations and rated high on the list at most others.

i. Breeding for curly top resistance. At Logan, Utah, and Prosser, Washington, selection for promising horticultural characters was continued among beet-curly-top resistant tomato lines and segregating populations. Performance trials were conducted at Farmington, Utah, on multiple disease resistance including curly top resistance. About 50 line and 10 individual plant selections were made for performance trials in 1964.

At Prosser, Washington, sugar beet-tomato row ratio tests were conducted to determine the most desirable ratio of beets to tomatoes in the tomato curly top virus resistant test planting to obtain optimum curly top virus infection at an early date. One row of beet to two rows of

tomato resulted in significantly higher infection in the tomatoes than 4 other planting ratios. Greenhouse tests indicate that 4-5 leafhoppers per plant previously fed on curly top virus infected sugar beets will eliminate 100 percent of the susceptible tomato plants.

At Prosser, Washington, tests in 1963 with isolates of the beet curly top virus from several locations in the west indicated wide variations in virulence among isolates.

B. Genetics

1. Tomatoes

a. Cross compatibility of Lycopersicon species. At Logan, Utah, seed was obtained from 79 interspecific crosses between L. esculentum and the wild, green-fruited species and 103 crosses between L. esculentum and interspecific cross progenies. These results indicate that the use of a wide range of complex genotypes as females in attempted interspecific crosses in the genus Lycopersicon will greatly increase the chances of success.

b. Genetic variation within inbred varieties. At Charleston, S.C., 13 selected lines from a commercial stock of Rutgers variety were grown in the third generation subsequent to selection. A moderate amount of genetic variation apparently has persisted in this highly inbred variety, and is perhaps associated with natural, as well as artificial selection.

C. Diseases

1. Peppers

a. Necrotic ringspot of pepper. A necrotic ringspot leaf symptom developed on about 10 percent of bell pepper plants in a field near Wapato, Washington, again in 1963. Two viruses were isolated from diseased specimens.

At Tifton, Georgia, an unidentified foliar disease of pepper appeared for the second year in plant beds on newly cleared land of two farms. Serological and inoculation tests indicate the causal agent is not the bacterial spot (X. vesicatoria) organism.

b. Identification of causal agent of disease through serology. An antiserum was developed that is specific to the bacterium Xanthomonas vesicatoria that causes bacterial spot of pepper and tomato. The technique enables identification of the organism within 2 hours of

receipt of the organism or diseased specimen and can largely eliminate the very time consuming isolation-inoculation-disease development technique previously used in identifying the incitant of this highly important disease.

c. Bacterial spot of pepper and tomato. Thirty-five isolates of the causal organism, Xanthomonas vesicatoria, obtained from Florida, Delaware, Indiana, and North Carolina, and three isolates from Israel were inoculated into pepper and tomato plants at Raleigh, N. C. No differences in pathogenicity were evident. The Pseudomonas sp. reported last year as associated with a bacterial leaf spot of pepper has been identified as P. syringae. Results of inoculations indicated that this organism will not be an important pathogen on pepper.

D. Culture

1. Tomato and pepper

a. Nutrition. At Tifton, Georgia, nutritional studies with tomato and pepper seedlings grown as transplants for northern production areas were conducted on newly cleared land simulating actual transplant production practices. In these studies yields of marketable plants were increased from 280,000 plants at the lowest nitrogen-phosphorus level to 537,000 at the highest nitrogen-phosphorus level with a corresponding decrease in number of cull plants. Similarly, yields of pepper transplants increased from 234,000 marketable plants at the lowest nitrogen-phosphorus level to 387,000 plants per acre at the highest nitrogen-phosphorus level. Commercial yields are about 100,000 plants per acre.

A high phosphorus content of tomato and pepper plants at transplanting was found to be essential to rapid recovery of transplant and vigorous subsequent growth and early fruit production. Chemical composition of transplants in relation to quality after transit and storage are to be investigated in 1964.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Breeding

Martin, M. W. and O. S. Cannon. 1963. Controlling tomato curly top by using resistant varieties. Utah Farm and Home Science 24:3-5, 25-26.

Diseases

Jaworski, C. A. and D. J. Morton. 1964. An epiphytotic of Pseudomonas solanacearum E.F.S. in tomatoes on newly-cleared Klej sand in relation to nutrient levels. Plant Disease Reprtr. 48(2):88-89.

- Morton, D. J. and T. J. Ratcliffe. 1964. A foliar disease of pepper seedlings in Georgia. Plant Disease Repr. 48(2):89.
- Ratcliffe, T. J. and D. J. Morton. 1963. Diseases affecting production of certified tomato plants in Georgia during 1942-1963. Plant Disease Repr. 47(12):1065-1066.
- Worley, R. E. and D. J. Morton. 1964. Ineffectiveness of calcium nitrate and other calcium sources in reducing Sclerotium rolfsii incidence on tomato under epiphytotic conditions. Plant Disease Repr. 48(1):63-65.

LEAFY AND MISCELLANEOUS VEGETABLES
Crops Research Division, ARS

Problem. Lettuce varieties are desired that will tolerate vacuum cooling and "dry" shipment. Tipburn, brown rib, bigvein, mildew and seedborne mosaic of lettuce are only partly solved or unsolved. Substantial genetic work is needed to develop ways to "stabilize" varieties of broccoli and brussels sprouts for different regions. Inheritance of flavor and other qualities needs to be determined in order to improve acceptability for both market and processing. Improvements in non-bolting, hardiness, and yield of cabbage are needed. Further work is needed on development of F₁ hybrids of crucifers and spinach. New breeding principles must be developed to improve range of adaptability and dependability of varietal performance in mechanized production and processing.

Most sweet corns grown in the South have been developed elsewhere for other conditions, and are not well enough adapted to the South. Corn earworm and *Helminthosporium* leaf blight are serious, necessitating expensive control measures. Productivity and attractiveness have generally been obtained at some expense to eating quality. Insect- and disease-resistant varieties and hybrids that are better adapted to the South and that produce and retain superior eating properties are badly needed. The desired properties must be sought out and ways developed for methodically incorporating them into commercially suitable types. Basic knowledge on the inheritance of economic characters is needed to attain these ends.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving services of geneticists, plant pathologists, and horticulturists in both basic and applied research. At Beltsville, Maryland, spinach breeding is done for developing resistance to blue mold, white rust, and mosaic. Research is also done to find the basis for best ways to produce F₁ hybrid seed. Work on lettuce is conducted at La Jolla, Brawley, and Salinas, California. Professional personnel at La Jolla develop lettuces adapted to the irrigated valleys of the Southwest. The work at Salinas is designed to serve all other parts of the country, and basic studies in population genetics are also in progress there. Resistance to mosaic and bigvein and to brown rib, tipburn, and other physiological disorders in lettuce is sought including those resulting from current methods of harvesting, cooling, and shipping lettuce. Mildew resistance is being incorporated into commercial types. La Jolla personnel cooperate actively with Texas and Arizona personnel on developments for those States. At Charleston, South Carolina, work is done to develop disease-resistant, hardy, non-bolting, productive cabbage of high quality for the Southeast and to develop basic genetic information.

Breeding sweet corn for resistance to earworm damage and to *Helminthosporium* leaf blight along with superior eating quality and adaptability to Southern growing conditions is being done at the U. S. Vegetable Breeding Laboratory at Charleston, S. C. Research is being initiated also on breeding broccoli at this laboratory.

The Federal scientific effort devoted to research in this area totals 3.7 professional man-years. Of this number 3.0 is devoted to breeding and genetics; 0.5 to diseases; and 0.2 to variety evaluation.

PROGRAM OF STATE EXPERIMENT STATIONS

Research on the culture of leafy vegetables is involved in 10 projects in eight States. Lettuce research includes cultural studies of irrigation levels and frequency, fertilizer rates and methods of application, and the effect of environmental factors on pink rib. Other research includes a study of nutrient intensity on growth, yield, and quality of cauliflower; plant growing practices, plant spacing, and nutrition of broccoli; cultural control of pencil stripe in celery; fertilization of cabbage; and methods of growing of spinach and other greens. Besides this research there are 60 general projects on culture of vegetable crops on record from 33 States.

Eighteen projects in 10 States are involved in the breeding of leafy vegetable crops. Crops receiving attention are lettuce, cabbage, cauliflower, broccoli, collards, celery, spinach, and cress. Lettuce breeding is aimed at incorporating resistance to tipburn, downy mildew, and big vein; heat tolerance; and desirable size into high quality lettuce adapted to local conditions. Cabbage breeding is concerned with incorporating resistance to diseases such as yellows, clubroot, blackrot, and downy mildew into locally adapted slow bolting varieties showing tolerance to both heat and cold. Some emphasis with crucifer breeding is directed toward development of F_1 hybrids. Celery breeding is concerned with resistance to *Cercospora*. Spinach breeding is aimed at development of varieties or hybrids that are resistant to diseases, and are acceptable for canning, freezing and fresh market.

Breeding research with leafy vegetables is supplemented and supported by genetic and cytogenetic investigations.

Research on diseases of leafy vegetables is variable in nature due to the range in crop varieties, culture conditions, and pathogenic agents involved. Some research projects are designed to provide information on the chemical control of diseases such as downy mildew in broccoli; club root in cabbage, root rot in lettuce, and rust in spinach. Techniques for the isolation of resistant germplasm to aid in control of these diseases are being developed at a few State stations. Research is continuing with studies on virus bigvein retention, multiplication, and the role of resting *olpidium* spores. New knowledge on obligate parasitism is being gained through histological and histochemical studies of downy mildew of lettuce.

Breeding of sweet corn in the northeastern States is coordinated by the NE-32 regional project on breeding sweet corn hybrids. The breeding objectives are resistance to earworm, northern leaf blight, smut, bacterial wilt, and low growing temperatures, earlier maturity, local adaption, and the application of male sterility and fertility restoration to hybrid seed production. The inheritance of genes with pronounced effect on the amount and kind of sugar in the endosperm is being studied.

The total research effort on leafy vegetables at the State stations is approximately 10.7 professional man-years; of which 3.1 is for culture, 5.3 for breeding and variety evaluation, and 2.3 for disease investigations.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Breeding

1. Head Lettuce. Mildew resistant lines developed from Great Lakes 65, Climax, and Forty-Niner were grown in the greenhouse at La Jolla, and their progenies tested at Brawley and in Texas. Eight advanced breeding lines were mass increased for extensive trials in Texas. Seven advanced breeding lines from an original cross between Parris Island Cos and dark green cos from Turkey (P.I. 167160) were tested in commercial fields in the Coachella Valley; two were outstanding for early maturity, color, size, and superior eating quality.

In the development of lettuce hybrids the male sterile character is being transferred to two commercial varieties to increase the rate of natural crossing, thereby increasing the ease of making F_1 hybrids. A test planting in the Imperial Valley during the winter of 1962-63 showed a crossing rate of 47.8% on the male sterile line compared with 2.0% on a normally fertile line.

The development of lettuce lines with genetic resistance to bigvein and lettuce mosaic was continued. Two F_2 families from crosses between selected plants which survived several mosaic inoculations were tested for increased level of resistance. In addition, four F_2 families from crosses between commercial varieties and mosaic resistant P.I. 251245 line of Lactuca serriola were likewise tested for resistance. Two hundred seeds each of the varieties Francisco and Great Lakes 118 were treated with the mutagenic chemical ethyl methane sulfonate in efforts to induce resistant segregates.

An experiment to detect the means of infection of lettuce seed with mosaic virus has been completed. The results indicate that most of the virus moves into the seed through the egg, but a small portion enters through the pollen.

Work on the inheritance of two leaf characters of lettuce has been completed. Of interest for the breeding program are two new male sterile characters, one from irradiated material and the other found in Calmar.

2. Cos or Romaine Lettuce. Work with cos type lettuce was continued. In an early test planting the new variety Valmaine (released in March 1963) and closely related lines proved to be superior to breeding material having Parris Island Cos and P.I. 167160 as parents. Plants of the latter material bolted early; they were short and of poor quality compared with Valmaine and lines related to Valmaine.

3. Spinach Improvement. In New Jersey in fall-planted trials two semi-savoy hybrids with combined immunity to two races of mildew and "blight" resistance were superior in productivity and processing quality to commercial varieties.

In Maryland, experimental Savoy Hybrid 59 was judged outstanding in yield and fresh market quality by growers, Experiment Station and Extension personnel.

Preliminary field and greenhouse trials indicate that several spinach lines possess tolerance to air pollution injury. Crosses have been made to develop lines and hybrids with a high level of tolerance to air pollution injury and with resistance to the major spinach diseases.

Two mildew and blight resistant spinach lines have performed exceptionally well in most areas from New Jersey to southern Texas. They are being considered for release early in 1965.

Three white rust resistant hybrids were equal to or better than commercial hybrids in yield and processing quality. The three resistant hybrids and eight additional promising hybrids were increased at La Jolla, California, for field trials in 1964.

4. Cabbage Breeding. Work continued at Charleston in developing cabbage for adaptability, slow bolting, and genetic male sterile types of value in hybrid cabbage. Some selected lines were highly self-incompatible. Glaze. Several families have been developed that are nearly true breeding for glaze (bright green leaves without the "bluish" waxy surfaces) most of which are very mild and especially suitable for fresh salad.

Ascorbic Acid. Analyses made on 494 heads of cabbage averaged higher than in previous years. A cross of Early Fuji produced heads ranging from 39.4 to 95.6 mg/100 grams ascorbic acid; also two heads selected from Greenback varied from 56.8 to 93.8 mg/100 grams.

Pollination. Evidence of lack of control of crossing under screenhouse conditions among four cabbage families was discovered during 1963. Using genetic markers, such as red and savoy, crossing varied from 2.5 to 34.6% and averaged 16.0%. Pollination in the screenhouse is probably done by insects small enough to go through most small mesh screens. Under screen-

controlled environment, four "non-pollinated" plants produced an average of 202 seed each and the germination of this seed was 78.7%.

5. Sweet Corn

a. Release of Inbreds. Fourteen new sweet corn lines were released from the cooperative program in Tennessee. The white lines were T11S and T15S; the yellow lines were C68R, T20S, T22S, T24S, T26S, T28S, T44S, T46S, and T60S. Each of these new lines possess some degree of resistance to the corn earworm.

b. Experimental Hybrids. Ten VBL hybrids grown in replicated trials were more resistant to the corn earworm than the Golden Security check. Three of these hybrids were selected by the Southern sweet corn cooperative group to be entered in the 1964 replicated trials. Two VBL hybrids were selected for repetition in the observational trials. In addition, two new VBL hybrids performed well enough in local trials to warrant their entry in the 1964 Southern Cooperative Observational trials.

c. Introduction of Inbreds. Six VBL inbreds - M97, M118, M822, Huron-3, Kiawah-A, and Wappoo-Q, have been released for use by seed producers and plant breeders. These inbreds have been used as parents in one or more hybrids that have performed well in the Southern Cooperative Sweet Corn Trials. All but Huron-3 have shown excellent resistance to the corn earworm, and M822, in addition, has resistance to Helminthosporium leaf spot.

d. Genetics. The incorporation of male sterility and restorer genes into VBL inbreds was continued through a backcross program. A similar program was initiated to develop lines carrying all possible combinations of the endosperm mutants, ae, du, wx, and su₁, with the idea of improving, or stabilizing, quality in sweet corn.

The search for new sources of earworm resistance was continued. Three P.I. field corn lines, Atkinson, Zapalote Chico, and Mexican June; four sweet corn inbreds from Dr. K. Starks, USDA Entomologist at Tifton, Georgia; two inbreds of the Glenn Smith material from Purdue University; and a hybrid from E. V. Walter, USDA Entomologist, West Lafayette, Indiana, were rated as highly resistant to the corn earworm. Also, ten BVL inbreds continued to show excellent resistance to the insect. Hybrids from these inbreds have ratings nearer the more resistant parent, indicating a partially dominant type of inheritance.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Breeding

- Leeper, Paul W., Thomas W. Whitaker, and G. W. Bohn. 1963. Valmaine.
A new cos-type lettuce variety. Amer. Veg. Grower 11(9):7, 16.
- Ryder, Edward J. 1963. An epistatically controlled pollen sterile in
lettuce (Lactuca sativa L.) Proc. Amer. Soc. Hort. Sci. 82:585-589.

MELON AND OTHER CUCURBIT CULTURE,
BREEDING AND GENETICS, DISEASES AND VARIETY EVALUATION
Crops Research Division, ARS

Problem. The major problems of melons, cucumbers, and related crops involve disease control through breeding or other means to permit production of optimum eating quality and yields. Varieties of good to excellent eating quality potentials often suffer serious field losses from disease, and the consumer is increasingly dissatisfied with poor quality that is due to diseases and premature harvest, especially in muskmelons. Improved carrying quality is needed. Resistance to some serious diseases is unknown, and available resistance to others has proved difficult to combine with the other economic characteristics needed. A disease complex of muskmelons called crown blight has seriously reduced production and acreage in the southwest and is not yet controlled. Potentials of F_1 hybrids and methods of their economical production need extensive study. Adaptation of the muskmelon and cucumber to mechanical harvesting are desired, as is adaptation of improved suitability of cucumbers for processing.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving geneticists, horticulturists, and plant pathologists engaged in both basic and applied research on melons and other cucurbits. Extensive muskmelon breeding and genetic studies are conducted at La Jolla, California, Brawley, California, and Charleston, South Carolina. Watermelon breeding is done at Charleston. Limited applied breeding of early, hardy cucumbers and squash is done at Cheyenne, Wyoming. Disease research with emphasis on crown blight of muskmelons is done at Beltsville, Maryland, and Mesa, and Tucson, Arizona, in cooperation with the Arizona Agricultural Experiment Station.

The Federal scientific effort devoted to research in this area totals 4.6 professional man-years. Of this number 2.9 are devoted to breeding and genetics and 1.7 to diseases.

PROGRAM OF STATE EXPERIMENT STATIONS

Cultural research with cucurbits at the State stations involves investigations of fertility and irrigation needs in relation to local environmental conditions. Fertility research is correlated with chemical tissue tests and soil analyses. Emphasis is placed upon increased yields and quality of the fruit. Seven projects in 5 States deal specifically

with the cultural needs of watermelons, cantaloupes, and cucumbers. Besides these projects there are 60 cultural projects of a general nature at 33 States designed to ascertain most effective cultural methods for vegetables in relation to local environmental conditions.

Considerable effort is made by the States to develop superior cucurbits possessing adaptation to local conditions. Watermelons; cantaloupes; muskmelons; cucumbers for pickles and fresh market; and squash receive attention. There is interest in the possibility of F_1 hybrids and in the "bush" character to facilitate mechanical harvesting. Emphasis is placed on quality of the fruit. The breeding work is supported by genetic and cytogenetic investigations. There are 26 active projects specifically on the breeding of cucurbits in 16 States.

Research on Verticillium wilt in Cucumis melo is designed to isolate sources of resistance to this disease, which can be used effectively in breeding work. In addition research on chemical control of this disease also offers promise. State stations scientists are concerned with many other disease problems in melons and other cucurbits. Histological investigations on gummy stem blight in watermelon has provided new information on seed infection which will aid in control of this disease. Other scientists have developed antisera for strains of wild cucumber mosaic virus which will be a valuable tool in detection and identification of these viruses. Studies on desert plants have shown recently that common species of Erodium are carriers of watermelon mosaic virus, which also causes poor set, and small, deformed fruit in cantaloupe. Such research may lead to efficient control of this destructive virus. Sources of resistance to cucumber scab, cantaloupe scab, and pumpkin powdery mildew are being sought through several research projects. The biochemical basis for virulence in the cucumber anthracnose fungus is being studied in two projects. Information gained from these projects will be valuable in helping to provide control for this disease. A number of scientists are studying nematode problems in cucurbit culture. Recent findings in studies on root knot nema of muskmelon indicate that the primary effect of these causal agents may be on the metabolism of the plant, rather than an immediate effect on uptake or translocation of minerals. Progress in this research affords an opportunity to contribute new knowledge which will eventually be of use in solving many nematode problems.

The total research effort on melons and other cucurbits at the State stations is approximately 16.1 professional man-years, of which 1.5 is for culture, 9.7 for breeding and variety evaluation, and 4.9 for disease investigations.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Breeding1. Muskmelons

a. Breeding for multiple disease resistance. In cooperation with California, Arizona and Texas Agricultural Experiment Stations, inbred derivatives of the powdery mildew-crown blight resistant cross P₃ x PMR 45 x PMR 450₃, and 30 odd other lines were evaluated in two acre blocks at Brawley, Calif., and in smaller blocks at several locations in California, Arizona and Texas during 1963. Five lines that resemble PMR 45 and 450 but with greater resistance to disease were increased with selection in isolated blocks. Studies of Honey Dew type lines resistant to crown blight and powdery mildew were continued.

b. Variety release. The cantaloup selection, 43786-M2, a high quality, productive PMR 45 type with high resistance to powdery mildew, moderate resistance to downy mildew was released to the seed trade as "Campo."

c. Watermelon mosaic. Six F₁ progenies, 5 F₂ progenies, and 15 B₁ progenies from crosses of WMR (watermelon mosaic-resistant) 90105 muskmelon with cultivars and PMR inbreds were subjected to selection in a half-acre block at Brawley. Some plants remained symptom-free at the end of the season.

Progenies from selections were indexed for WMV-1 resistance and powdery mildew resistance at La Jolla and Beltsville and used in controlled breeding.

d. Cucumber mosaic. Nine BC₁ muskmelon progenies from CMR F₂ selections x PMR inbreds were planted in the greenhouse at La Jolla and transplanted in a half-acre block at Brawley. Progenies from fruit quality selections are being evaluated in CMV index tests in the greenhouse at La Jolla. Similar studies are conducted at Beltsville.

The trihybrids CMR 34340 x WMR 90105 x PMR 110M2 and CMR 34340 x WMR 90105 x PMR 13564 were made and inbred to secure plants resistant to three diseases indicated and to crown blight.

e. Breeding for resistance to crown blight. At Mesa, Arizona, in cooperation with the Arizona Agricultural Experiment Station, one crown blight resistant muskmelon selection was grown in comparison with PMR 45 in observation trials at Mesa and at Yuma. In both plantings the crown blight resistant line produced more vigorous vines and more fruit over a longer period of time than PMR 45. At Mesa, the resistant line had only 7.8% crown leaf decline vs. 43.2% in PMR 45. This crown blight resistant line is undergoing further selection and evaluation.

Crown blight resistance is being transferred into commercially accepted strains. Hybrids between crown blight resistant lines and selected commercial varieties are being tested to determine the feasibility of crown blight control through the use of F_1 hybrids. Use of vegetative propagation of muskmelons will materially hasten breeding for resistance to crown blight.

f. Development of breeding methods. In a cooperative study by the Charleston, S.C. and western projects to compare efficiency of breeding procedures, preliminary results indicate that selection of fruit and plant characters by index in successive isolation block plantings may be highly productive in securing favorable recombinations of those characters necessary for adaptability and productivity under a wide range of environmental conditions.

g. Genetics and cytogenetics. In cooperative studies with the University of Arizona at Mesa, a linkage test of male-sterile 1 with the seedling marker yellow-green was confounded by aberrant behavior of some plants. Causes of the aberrant behavior are being investigated.

Cooperative studies with the University of California at Davis demonstrated that normal and "bush" plant types segregate in a monohybrid proportion in F_2 progenies from crosses of normal with both of two "bush" cantaloups. F_2 progenies for genetic analysis from the cross Hardin's Bush x Big River Bush were also secured.

Cooperative studies between La Jolla and Beltsville on the genetics of resistance to WMV-1 demonstrated two distinct dominant genes for resistance.

Meiosis in male-sterile 2 cantaloup, like that in male-sterile 1, was found to be normal, yielding 4 microspores each with a complement of 12 chromosomes. Most microspores contained one nucleolus but two also occurred. This variation was irregular in occurrence.

B. Diseases

a. Ringspot of watermelon fruit. At Tifton, Georgia, a ringspot disease of watermelon fruit was associated with plant infection by the watermelon mosaic virus 2 (WMV). A similar relationship was established between fruit spotting and the presence of WMV-1 and WMV-2 in watermelons growing in the vicinity of Wapato, Washington. Tests at Beltsville, Md., confirmed that fruit spotting and malformation in 12 watermelon varieties can be caused by infection with either WMV-1 or WMV-2 or both together in the same plant.

b. Unknown muskmelon virus. At Beltsville, Maryland, the unidentified virus affecting muskmelons on the Mesa, Arizona, Agricultural Experiment Station has been named the muskmelon necrotic fleck virus. Physical properties are: dilution end point, 1:1,000,000; thermal inactivation, in 10 minutes between 65 and 70°C; longevity in vitro, greater than 15 months at 65°F. Two transmission trials indicate that the green peach aphid (Myzus persicae Sulz) is not an efficient vector of this virus.

c. Separation of watermelon mosaic viruses. At Beltsville, Maryland, in cooperation with the Pioneer Virology Laboratory, biological and serological tests conducted with 10 isolates of the watermelon mosaic virus (WMV) from the major muskmelon production areas of the United States, show that WMV actually consists of two distinct viruses. They possess similar physical properties but differ widely in host ranges and are not serologically related. They have been designated as WMV-1 (Frietag's type) and WMV-2. A survey of the prevalence of these two viruses in the southern and western United States shows that both occur in most production areas with WMV-2 more prevalent in certain areas.

d. Muskmelon stunt. At Tucson, Arizona, in cooperation with the Arizona Experiment Station the watermelon stunt virus isolated from diseased muskmelon in the Yuma area is an unusual strain of the squash mosaic virus.

e. Virus assays in muskmelons. In cooperative studies between La Jolla and Beltsville, virus assays of muskmelons grown at Brawley demonstrated that natural infection by WMV-2 (watermelon mosaic virus 2), CLV (cantaloup latent virus), and CMV (cucumber mosaic virus) occurred in plants resistant to WMV-1. Some WMV-1 susceptible plants harbored all 4 viruses. Similar assays of cultivars suggested that WMV-2 and CLV were more prevalent than WMV-1 in muskmelons at Brawley and Blythe. CMV was rarely recovered.

f. Epidemiology of cucurbit virus diseases in the vicinity of Yuma, Arizona, and Brawley, California. At Yuma, Arizona, in cooperation with the Arizona Agricultural Experiment Station cucurbit virus surveys indicated virus infection in the 1963 spring muskmelon crop was the lowest during the past 7 years. In 1963 the overall area wide average incidence of virus infection was 25%. Virus incidence varied from 40% in Central Yuma Valley to 8% in Dome Valley. Muskmelon vines generally remained in excellent condition throughout the growing season. Intensive virus surveys the past 4 spring seasons in the Yuma area have shown a close correlation between early aphid and virus infiltration into the muskmelon crop and production losses. WMV and the cucurbit latent virus (CLV) continued to be the viruses most often isolated from diseased plants except in two localized areas where the cucumber virus was also abundant.

2. Cucumbers

a. Improvement for the High Plains. Crosses were made using 5 widely adapted slicer cucumber varieties and the high quality disease susceptible variety Jalalabad. Second generation seed were obtained in the greenhouse during the winter and selections for earliness, fruit quality, possible disease resistance and fruit production will be made at Cheyenne in 1964. Evaluation of advanced lines will be made with the Kurer-Empson firm in Colorado.

3. Watermelons

a. Experimental tetraploids. The first commercial interest in tetraploid watermelons has developed following release of 3 tetraploid stocks in 1962. Growers are impressed by the superior flesh quality and probably long storage potentialities in a good tetraploid. Flesh quality of Tetra 1, Tetra 2, and Tetra 3 is equal to that in the best triploids, and the rind is extremely hard. The number of seed per melon is intermediate between that of a diploid and a relatively seedless triploid. Tetraploid stocks are being improved by sib-crossing and mass selection.

b. "Seedless" watermelons. Using the 3 released tetraploids as female parents, systematic crosses were made with 5 diploids to produce 15 experimental seedless watermelons for testing with cooperators. A few of these have proved to be good. Efforts to separate tetraploid and triploid seed by flotation in mixtures from open-pollinated tetraploid fruits continued and specific gravity determinations were made on 48 lots of seed.

c. F₁ hybrids. A systematic program of production and evaluation of diploid hybrid watermelons was begun. Certain F₁ hybrid watermelons appear to have much merit. Some varieties which are too late ripening for commercial use make especially good parents in hybrid production when crossed with early varieties.

d. Breeding methods. Breeding technique was changed this year almost entirely to isolation plot techniques and to enforced sib-crossing. A few bulk lots were increased in full isolation in preparation for commercial trials. Individual lots (41) in the minimum isolation group were mass selected for various types. Selections from citron crosses (for resistance to gummy stem blight and race 2 of anthracnose) and from a Colocynthis x Vulgaris cross, all look very unpromising at present.

e. Disease resistance. Controlled tests for resistance to anthracnose and fusarium wilt were resumed. Resistance to race 2 of anthracnose seems probably attainable through new citron accessions from South Africa.

4. Other Cucurbits

a. Interspecific hybridization. At La Jolla, 15 species of cucurbita, 9 collections of different cultivated species from Mexico and 35 progenies of various species hybrids were grown in the field. Observations, photographs, and self and cross pollinations were made with this material. Progress is being made in transferring genes for resistance to powdery mildew from wild species to material that is similar to our best domesticated squash and pumpkin cultivars.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Breeding

Bohn, G. W., C. F. Andrus, R. T. Correa, Bruce Perry and H. M. Meyer. 1963. Muskmelon breeding. Cooperative muskmelon trials in the Lower Rio Grande Valley 1963. Assembled and mimeographed for limited distribution to researchers, cooperators, and supervisors.

Whitaker, Thomas W. 1962. An interspecific cross in cucurbita: C. lundeliana Bailey x C. maxima Duchesne. Euphytica 11(3):273-281.

Diseases

Morton, Donald J. and Raymon E. Webb. 1963. A ringspot of watermelon fruit in Georgia associated with watermelon mosaic virus. Phytopathology 53:624.

Morton, Donald J. and Raymon E. Webb. 1963. Symptoms associated with watermelon mosaic virus in south Georgia. Plant Disease Reporter 47(8):772-773.

Skotland, C. B., R. L. Clark, and R. E. Webb. 1963. Watermelon mosaic virus in Washington. Plant Disease Reporter 47(8):774-775.

Webb, R. E. 1963. Local lesion hosts for some isolates of the watermelon mosaic virus. Plant Disease Reporter 47(11):1036-1038.

MUSHROOM BREEDING AND GENETICS, DISEASE AND CULTURE

Crops Research Division, ARS

Problem. Materials and methods of the old craft of mushroom production no longer suffice under current conditions. Considerably more information on the cytogenetics of the common mushroom is needed to permit controlled "breeding" and improvement. Extensive basic studies of the microbiology of the composting materials, nutrition and environmental physiology of various fungi, and the diseases and cytogenetics of edible fungi must be conducted to place the industry on a sound footing.

USDA AND COOPERATIVE PROGRAM

Applied and basic mushroom studies are conducted at Beltsville on "artificial" or substitute composts and nutritional and environmental effects on mushroom growth, yield, and quality. In addition studies are under way to devise effective breeding and genetic studies to improve mushroom strains in yielding ability and quality on the water loss from growing mushrooms, and on the casing soil area/compost volume ratio on the growth and yield of mushrooms. Two professional man-years were involved in F.Y. 1964.

PROGRAM OF STATE EXPERIMENT STATIONS

Three States are engaged in cultural research for mushrooms. The Pennsylvania station is endeavoring to develop an improved nutrient substrate for growing mushrooms and is studying factors controlling the size and quality of sporophores. It is also interested in developing better methods for processing canned mushrooms. The New York station is studying the influence of ionizing radiations upon compost as to its ability to support growth of fungal mycelium for commercial mushroom production and is interested in determining the reasons for any advantageous benefit derived. Research in Mississippi is designed to determine if mushrooms can be produced in Mississippi on composted materials from by-products of agriculture and forestry, and to study cultural requirements of mushrooms when grown in Mississippi.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

Transpiration. The loss of water from the surface of normal, intact, growing mushrooms was determined. During growth the mushroom fruit lost a quantity of water equal to about one half of its fresh weight. Water loss from mushrooms of different size was proportional to the surface area of the mushroom and found to be equivalent to the water lost by evaporation from a free-water surface of similar area.

Casing soil area. In a study of the effect of the casing soil area/compost volume ratio on the growth and yield of mushrooms specially constructed growing trays and plastic sheeting provided different soil/compost ratios. It was found that once the conditions for a proper casing layer are met, mushroom production is essentially independent of the area of this layer.

Pilot scale composting. During the past 3 years a small scale system of composting was developed to simulate composting in the large heaps used by commercial growers. The compost produced is similar in most respects to commercial mushroom compost and yields a satisfactory crop of mushrooms. The new procedure provides: 1) a pilot scale means of studying the effect of subsequent yields of various factors operating during composting, and 2) a means of rapidly and economically screening many industrial wastes for possible use in commercial mushroom composts.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

- Lambert, E. B. and T. T. Ayers. (1962) 1963. Techniques for isolation of paired spores from a single basidium of the cultivated mushroom. Proc. 5th Inter. Conf. Mushroom Sci. 185-187.
- Lambert, E. B. (1962) 1963. Cropping experiments to test the efficiency of nutrient translocation by cultivated mushrooms. Proc. 5th Inter. Conf. Mushroom Sci. 340-347.
- San Antonio, J. P. (1962) 1963. Breakdown of chlorinated insecticides in mushroom compost. Proc. 5th Inter. Conf. Mushroom Sci. 518-524.
- San Antonio, J. P. and E. B. Lambert. (1962) 1963. Effects of pesticides in casing soil on growth and development of cultivated mushrooms. Proc. 5th Inter. Conf. Mushroom Sci. 327-339.

SEED CROP CULTURE,
PHYSIOLOGY, NUTRITION AND HARVESTING
Crops Research Division, ARS

Problem. Although the vegetable seed industry normally produces adequate quantities of seeds, in seed production there is still too much risk, too low economic efficiency, and too much variability in quality. The industry is geographically concentrated, and thus subject to localized hazards which could drastically affect the entire national vegetable production and processing industries. The vegetable seed industry has developed to its present level almost entirely by trial and error. Now the development of high mechanized methods in vegetable production is demanding the production of higher quality seeds. However, basic knowledge is lacking on the physiology of seed development, maturation, and germination, particularly in reference to the crop producing potential of the seeds. Thus, applied research by industry and government lacks the sound scientific basis necessary for future advances.

USDA AND COOPERATIVE PROGRAM

Vegetable Crops. Basic research on the physiology and biochemistry of vegetable seed germination and seedling vigor is carried out at Beltsville, Maryland. At Logan, Utah, in cooperation with the State Agricultural Experiment Station, emphasis has been shifted from cultural studies on vegetable seed production to research on the physiology of seed development. A program is being developed to investigate seed quality factors such as light and temperature sensitivity, dormancy, and seedling vigor. Federal scientific effort totals 3.0 professional man-years, of which 2.0 are on germination physiology and biochemistry and 1.0 on the physiology of seed development.

Research is underway in India on a P.L. 480 contract (1961-66) funded at \$60,562 to study physiology of development of fertilized and unfertilized ovules.

PROGRAM OF STATE EXPERIMENT STATIONS

Scientists at the State Experiment Stations are engaged in basic and applied research in physiology, pathology, agronomy and engineering pertaining to seeds. In many States, the research is conducted cooperatively with the Department. This research is continuing to provide useful fundamental information for the improvement of seed crop culture, harvesting and storage. Two regional projects have been organized by the States to coordinate research on seed problems. In the Northeastern region under NEM-22, quick methods of determining varietal purity of alfalfa and red clover are being sought with the aid of field and laboratory facilities. In the Western region under WM-35 much attention is being given to developing and improving techniques for rapid estimation of viability of seed, factors during growth

affecting viability, harvest and storage factors relating to poor germination, and improved laboratory methods of determining the viability of and purity of range grass seed. Other studies concern management of seed production fields for forage seed, control of insects, effect of growing conditions on seed quality, harvesting equipment, and drying practices. Seed storage research concerns factors associated with seed deterioration, the sequence of physiological changes, storage factors affecting these changes, seedborne microflora, and the use of seed coatings. Testing procedures for germination, vigor, and stand-producing potential are receiving much attention. Some work is being done on blending seed for uniformity. Various means of breaking seed dormancy including radio-frequency electric fields are being explored. In addition to studies on seed production and seed technology most of the States are involved to some degree in producing breeder, foundation and certified seed of newly developed crop varieties.

Disease problems involve all of the major seed crops of vegetables, ornamentals, forages, and field crops. In many instances they are known to limit production. In addition, with increased demand upon seeds to provide a plant that is highly tailored to meet an array of components affecting culture, harvesting, processing, and product quality, the need for knowledge on disease problems has increased. Likewise, as new information on the normal physiology of seed and seed development is being accumulated, the importance of fundamental knowledge on the abnormal physiology; i.e. the pathology, becomes increasingly evident. Some of the research in progress is designed to provide new knowledge on specific causal agents of disease. In other projects, scientists are concerned with isolating the components of resistance to disease, so that these may be used by plant improvement specialists and others to provide resistant plants of commercial value. A number of projects are designed to provide the critical histological and histochemical evidence that is essential to the study of certain seed crop diseases. The role of fungi and bacteria in the deterioration of seeds is being emphasized in some projects.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

Temperature relations in lima bean germination. At Beltsville, Maryland, previous work has been concerned with defining seedling vigor in precise physiological and biochemical terms, using bleached (low vigor) and green (high vigor) lima bean seeds. It was found that lima bean seeds are sensitive to low temperature, bleached seeds being somewhat more sensitive than green. Furthermore, it was discovered that the growth rate of excised embryonic axes at the optimum temperature is determined by the temperature during early imbibition. The lower the temperature (in the range 25°C. to 5°C.) the lower the subsequent growth rate. This effect persists during the entire period of growth possible in the excised axis. The temperature sensitive period for injury is short, about 10 minutes, during which the axis reach approximately 50% water content. If axes are imbibed at 25°C. and then transferred to low temperatures, no injury occurs, i.e. the axes have been protected. The sensitive protection period is the same as that

during which injury can occur. Low temperature injury is marked by leaching of materials from damaged axes, and low vigor axes are more easily injured than those with high vigor. The same phenomenon occurs in intact seeds. These and related results suggest that physiological and biochemical activity during the early stages in water uptake of a seed are much more critical than had previously been realized.

WEED AND NEMATODE CONTROL
Crops Research Division, ARS

Problem. Weeds cause losses in crops, orchards, grazing lands, forests, water supplies, and irrigation and drainage systems. The losses caused by weeds can be reduced by finding more effective chemical, biological, mechanical, cultural and combination methods of weed control. Improved weed control methods will facilitate farm mechanization, increase production efficiency, and improve the efficiency of the use of human and land resources in agriculture.

Plant-parasitic nematodes occur in all soils used for growing of crop plants and attack all kinds of plants grown for food, forage, fiber, feed, or ornamental purposes. It has been long known that severity of attack by certain fungi is greatly increased if nematodes are present; and nematodes have been known to be the vectors of several plant viruses. There is a need for improvements in the methods of controlling nematodes by crop rotations, cultural practices, chemicals and biological methods on vegetables.

USDA AND COOPERATIVE PROGRAM

The total Federal scientific effort devoted to weed control research was 57.5 professional man-years, of which 2.7 was devoted to weed control in vegetable crops in New Brunswick, New Jersey; Weslaco, Texas; and at Tifton, Georgia.

The Federal scientific effort devoted to research on nematode identification, physiology, and control was 19.0 professional man-years in F.Y. 1964, of which 2.5 were devoted to work on vegetables at Tifton, Georgia; Charleston, South Carolina; and Weslaco, Texas.

PROGRAM OF STATE EXPERIMENT STATIONS

All the State experiment stations are conducting basic and applied research in weed control. These studies involve evaluation of selective herbicidal properties of new chemicals to show the relation between chemical structure, herbicidal activity and weed-crop selectivity; the nature, behavior, and effect of herbicides on their degradation products in and on plants and plant products; the mechanism of herbicidal action; influence of climate, plant morphology and soil characteristics on the effectiveness of herbicides in selectively controlling weeds and on their persistence in plant tissue. Studies are being conducted on the movement and persistence of herbicides in various soil types and the phenomena involved in absorption and other interaction of herbicides with clay complexes.

Weed life cycles and growth habits are being studied under different environments to determine the most susceptible stage of vulnerability to herbicides and other control measures. Other aspects that are currently being investigated are: competition between weeds and desired plant successions following control measures including replacement vegetation and management practices. Relation between weeds and biological control organism that attack them in different environment is being studied on a limited scale.

Much of the basic research in weed control is being done via six regional projects as follows: W-52 is exploring the fundamental biochemical and biophysical processes involved in herbicidal action; W-63 is studying the chemical and physical properties of herbicides in relation to environment and effectiveness; NE-42 is investigating weed life cycles and light as factors in weed control; NC-61 is concerned with the nature and extent of competition between weeds and crops; S-18 and NE-42 are investigating the behavior of herbicides in soil, the physiological aspects of certain herbicides and life histories of important southern and northeastern weed species. CRF-1 program is attacking basic problems in aquatic weed control and brush control. The USDA cooperates on much of this research activity.

The total State scientific effort devoted to weed control research is 344.1 professional man-years.

Nematode investigations are being conducted at most of the State Stations and many of these scientists participate in the four Regional Research Projects concerned with phytonematology. Through these and other projects at the various institutions scientists are contributing new knowledge on the genetics, physiology, and pathology of nemas. Some station scientists, as a result of their recent findings on nemas as vectors of viruses, are conducting intensive investigations of the biologies of this process. Other research on fundamental problems in nematology as well as work on identification and control are indicated in the appropriate crop section of this report.

The total research effort on Nematode Identification, Physiology, and Control at the State Stations is approximately 52.2 professional man-years.

PROGRESS - USDA AND COOPERATIVE PROGRAMS

A. Weed Investigations

Asparagus. A long term experiment was initiated at New Brunswick, New Jersey, in the spring of 1963, to study the continued use of a number of herbicides on asparagus. Herbicides presently included in these studies are monuron, DCPA, amiben, diphenamid, linuron, simazine, and dichlobenil. Outstanding results were achieved with linuron, amiben, and dichlobenil during the 1963 season.

Cabbage. Trifluralin at 3 lb/A reduced the yield of cabbage when the applications were soil-incorporated before seeding at Weslaco, Texas. Herbicidal rates of trifluralin, CDEC, DCPA, and ethyl di-*n*-butylthiolcarbamate did not affect the growth of cabbage regardless of application methods.

Cantaloupes. In experiments on weed control in cantaloupes in Texas, CDEC performed best when soil-incorporated but required delayed seeding for selectivity. CDEC + DCPA controlled weeds selectively regardless of incorporation. DCPA controlled weeds better when incorporated but tended to reduce yields. NPA was ineffective. Petroleum mulch increased soil moisture and temperature but had no effect on the preemergence activity of CDEC. CDEC does not penetrate the sandy clay loam characteristic of this area of Texas without incorporation. Incorporated CDEC migrated into the soil surface layer in three weeks and was entirely dissipated after six weeks.

Carrots. CIPC, trifluralin, and DCPA with petroleum mulches controlled test species such as ryegrass and sudangrass more efficiently in carrot plantings in Texas than when these herbicides were used in unmulched soil. PEBC controlled grasses efficiently when applications were oversprayed with mulch or were unmulched. None of the herbicide treatments reduced the carrot yields.

Eggplants. In experiments in New Jersey, excellent weed control was obtained in eggplants with either PEBC or diphenamid when used in combination with a petroleum mulch.

Lettuce. In Texas, preplanting and soil-incorporated applications and preemergence applications of CIPC, CDEC, ethyl di-*n*-butylthiolcarbamate, and trifluralin were studied for broadleaved weed control in lettuce on furrow irrigated sandy clay loam. Trifluralin controlled weeds at the 1 and 2 lb/A rates regardless of the application method. CDEC controlled weeds more efficiently when soil-incorporated. Petroleum mulch had no significant effect on the performance of preemergence applications of CDEC. CIPC and ethyl di-*n*-butylthiolcarbamate failed to control weeds regardless of the rate or method of application. Petroleum mulch increased the temperature of the soil and its use was accompanied by reduced germination of the lettuce. The yield of lettuce was reduced when planted following cotton treated with diuron regardless of irrigation methods, soil incorporation, or the use of petroleum mulch. The yields of lettuce were also reduced in plantings following postemergence application of diuron, DCPA, and prometryne in cotton.

Onions. In Texas, PEBC applied alone as a preemergence treatment increased the percentage of distorted bulbs though the herbicide did not injure the crop when the same rates were applied followed by a petroleum mulch spray. Onions showed a high tolerance to CDEC and DCPA regardless of method of application.

Peppers. Incorporation of the granules of diphenamid and PEBC in a petroleum mulch gave excellent weed control in transplanted peppers in New Jersey.

Spinach. In Texas, granular CDEC controlled broadleaved weeds better but injured spinach more than did liquid CDEC. Outstanding results were achieved when CDEC was applied at a rate of 6 lb/A as a preplanting soil-incorporated treatment. All of the herbicides studied injured spinach when incorporated at seeding but none caused injury when they were incorporated before seeding.

Sweet potatoes. Sweet potato slips were very tolerant of amiben and diphenamid applied at transplanting time in experiments in Georgia. None of the herbicides tested reduced sweet potato quality.

Tomatoes. Preemergence applications of PEBC caused appreciable damage to seeded tomatoes in Georgia at herbicidal rates, diphenamid appeared relatively safe as a preemergence treatment and delayed preemergence DPA treatments were not injurious. A combination of DPA plus diphenamid gave improved residual activity. Crop and weed responses were most favorable with amiben, diphenamid, and PEBC used at transplanting and layby in transplanted tomatoes. Applications of granular PEBC preceding a petroleum mulch gave excellent weed control.

B. Nematodes

Vegetables. At Charleston, South Carolina, two Plant Introduction accessions were found with marked resistance to the cotton root-knot nematode, Meloidogyne incognita acrita, and are being used in breeding to incorporate resistance into commercial bush bean varieties. A Cucumis introduction with resistance to this nematode has been found, but attempts to transfer the resistance to cucumbers have so far been unsuccessful. Chromatographic studies of the nature of root-knot nematode resistance have indicated that an antigen-like substance may be involved, producing an effect on the nematodes in the early stages of infection.

Experiments at Baton Rouge, Louisiana, have shown that the reniform nematode (Rotylenchulus reniformis) is a very damaging pest of sweet potatoes. In an experiment with nematocides, it reduced yields of saleable roots by 61 percent when the untreated control plots were compared with the average of the three best treatments. It was very effectively controlled by dichloropropene and dichloropropane (D-D Mixture) and by a mixture of dichloropropene and methyl isothiocyanate.

At Tifton, Georgia, it was found that yields of sweet corn were reduced by 37.5 percent and numbers of tomato transplants by 51 percent where nematodes were not controlled. It was also found that the Georgia marigold (Tagetes minuta) may be valuable as a nematode-reducing cover and

rotation crop in that region. It was highly effective in reducing sting, root-lesion, dagger, ring and stubby-root nematodes. It grows to a height of about 6 feet, shading out weeds during the late summer months.

Under a P.L. 480 Project at La Molina, Peru, it was found that larval emergence of the golden nematode of potatoes was greatest at 13.5°C. More larvae were obtained at 5° and 10°C than at 20° or 25°C; none were obtained at 30°C.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Weed Control in Vegetable Crops

- Taylorson, R. B. 1964. Some properties of a growth inhibitor in Ipomea. Proc. SWC, p. 370.
- Taylorson, R. B. 1964. Herbicides for seeded tomatoes. Proc. SWC, pp. 207-214.
- Welker, W. V. 1964. Effect of herbicides on quality and yield of sweet potatoes. (Abstract) WSA, p. 37.

Nematodes

- Fassuliotis, G. and G. Rau. 1963. Evaluation of Cucumis spp. for resistance to the cotton root-knot nematode, Meloidogyne incognita acrita. Plant Dis. Repr. 47(9), p. 809.
- Good, J. M. and H. W. Rankin. 1964. Evaluation of soil fumigants for control of nematodes, weeds and soil fungi. Plant Dis. Repr. 48(3), pp. 194-199.
- Ravines, Albert Martin, Jose Diaz Flores, Alfredo Garcia Goyochea, Juan E. Simon F. 1963. El nematode dorado de la papa. Estacion Experimental Agricola de L. Molina Boletin No. 6, pp. 1-20.

INSECT CONTROL

Entomology Research Division, ARS

Problem. Insects and mites are important limiting factors in the production of high-quality vegetables. These pests reduce yield, lower quality, spread plant diseases, contaminate the marketable product, and increase the cost of production. Use of insecticides and miticides is currently the most effective direct method of control; however, application too close to harvest may result in residue problems. There is concern over the possibility of contaminating milk and meat by feeding crop refuse or byproducts of peas, beans, sweet corn, or other vegetables treated with insecticides to livestock. Drift of certain insecticides into other fields or areas can also cause problems. Another difficulty is that a number of vegetable insects have developed resistance to certain insecticides. There is an increasing need for safe, effective, and economical methods of control that will not leave harmful residues on the marketable produce or adversely affect the flavor or quality. Research is needed on methods for better utilization of predators, parasites, and diseases of vegetable insects; development of varieties of vegetables resistant to insect attack; development and utilization of more effective traps and lures; new approaches to control including radiation, chemosterilants, and antimetabolites; and evaluation of insecticide application equipment. Availability of effective non-insecticidal methods of control would decrease the necessity for employing hazardous chemicals. Better methods are required to forecast possible insect damage before it occurs on vegetables, and to determine when it will be necessary and profitable for growers to apply control measures.

USDA AND COOPERATIVE PROGRAMS

The Department has a long-term program of applied and basic research on vegetable insects with stations at Mesa, Ariz.; Riverside, Calif.; Tifton, Ga.; Twin Falls, Idaho; West Lafayette, Ind.; Beltsville, Md.; State College, Miss.; Forest Grove, Oreg.; Charleston, S.C.; Logan, Utah; Baton Rouge, La.; and Yakima, Wash., in cooperation with the respective State experiment stations and industry. Much of the work is in cooperation with the Crops Research, Pesticides Regulation, and Agricultural Engineering Research Divisions. Work in Idaho is also cooperative with the Idaho Bean Commission and that in Maryland with the Northern Utilization Research and Development Division and the Human Nutrition Research Division. Work in Oregon is conducted jointly with the Agricultural Engineering Research Division. Work in Louisiana is under contract to the Louisiana State Experiment Station.

The major objective of this work is to develop more effective and economical and less objectionable methods of controlling insect pests of vegetables in the field to reduce losses from these pests without leaving undesirable insecticide residues on or in the marketed product or in the soil, and

without affecting the flavor or quality of the product, or adversely affecting beneficial insects. In this research increased emphasis is being given to new approaches to insect control, and to the development of a sound biological basis for application of non-insecticidal methods. A widespread search for sex lures that can be utilized in insect detection and control is in progress. Also underway are studies of male sterilization techniques for insects such as the cabbage looper, drosophila, the banded cucumber beetle, and the Mexican bean beetle, utilizing gamma radiation and chemical sterilants. Such methods may permit control on an area basis.

The Federal scientific effort devoted to research in this area totals 24.8 professional man-years. Of this number 4.8 is devoted to basic biology, physiology, and nutrition; 4.1 to insecticidal and cultural control; 4.1 to insecticide residue determination; 2.9 to biological control; 3.0 to insect sterility, attractants, and other new approaches to control; 2.1 to evaluation of equipment for insect detection and control; 1.7 to varietal evaluation for insect resistance; 0.8 to insect vectors of diseases; and 1.3 to program leadership.

PROGRAM OF STATE EXPERIMENT STATIONS

Research on vegetable insects at the State experiment stations is designed to provide both basic and applied information. Emphasis is being placed on developing methods for reducing the number of insecticide applications required for control. Population levels of injurious species necessary to cause economic damage are being determined. Insect predators and parasites are under investigation to determine what practices contribute to their increase. Microorganisms pathogenic to insects such as the polyhedrosis virus of the cabbage looper are being evaluated for their effectiveness. Fundamental studies on the influence of environmental factors on diapause, movement, and population size of injurious insects are being performed as methods for laboratory rearing of insects become more refined. Plant resistance and strip-planting of vegetables with other crops are promising areas under investigation. Methods of insecticide application which reduce the amount of chemical applied directly to the plant and the development of insecticides with greatly reduced residual properties are important current research areas. Studies also are being performed on the insect transmission of vegetable diseases.

The total State scientific effort devoted to vegetable insect research is 45.3 man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Basic Biology, Physiology, and Nutrition

1. Leaf Miners. Further studies on the leaf miners that have damaged vegetables in Florida and South Carolina and chrysanthemums in Northeastern

greenhouses showed that these insects belong to the species Liriomyza munda Frick. Infestations on tomatoes were much lower in the Charleston area during the spring of 1964 than in several preceding years.

2. Sweetpotato Insects. In studies at Charleston, S.C., 3 new pests of roots of sweetpotato were discovered, including Plectris aliena, a white grub; Systema frontalis, a flea beetle; and Notoxus calcaratus, an anthicid. Considerable evidence was obtained that the tobacco wireworm damaged sweetpotato roots in Georgia.

Continued studies under contract by the Louisiana State Agricultural Experiment Station indicated that populations of banded cucumber beetle may normally be in delicate balance with predators of the pest and that the use of insecticides must be carefully controlled to avoid upsetting that balance. Fat accumulation in adult banded cucumber beetles was highest in August and higher in beetles from sweetpotato fields than in those from soybean fields. A higher percentage of mated females from sweetpotato fields contained eggs. Damage to sweetpotato roots by larvae of banded cucumber beetle and pale-striped flea beetle was similar. Adults of banded cucumber beetles were most abundant in July. Sticky traps painted bright yellow caught the most beetles. Pseudoplusia includens caused considerable defoliation of sweetpotatoes.

3. Adult Cabbage Looper Diets. In California, cabbage looper moths fed on 10% sucrose lived longer and deposited more eggs than when fed on other diets tested, including in decreasing order of effectiveness (1) 5% sucrose with 5% honey and .1% ascorbic acid, (2) distilled water, and (3) 5% yeast hydrolyzate.

4. Cabbage Looper Mating and Oviposition Studies. Also in California, 10-minute exposure to cold (50° F.), carbon dioxide, or ether, reduced mating during the following 24-hour period 4%, 58%, and 89%, respectively. Size of various types of cardboard or wire screen cages had no effect on mating with 1-5 moth pairs per cage. Mating was increased from 35% to 83% in 48-hour mating periods when the ratio of the males to females was increased from .25 to 4.

In mass rearing studies, the number of moths per container affected oviposition and longevity. Optimum moth density was determined to be 3-6 pairs for 1 pint cartons and 24-48 pairs for 6-quart oviposition chambers. Looper oviposition was increased 3-fold in the presence of UV (ultraviolet) light vs. red light and 6-fold in the presence of UV vs. yellow light.

5. Cold Effects on Cabbage Looper Eggs and Pupae. In California, the viability of looper eggs was unaffected by exposure to 50° F. for 1 or 2 weeks. Marked reduction in hatch occurred when eggs were held at 40° F. for the same periods of time.

A high percentage of adults from 4-day-old pupae exposed to 50° F. for 1 or 2 weeks were deformed. Emergence from 6-day-old pupae exposed to 50° F. for the same period of time was normal. Adults emerging from 4- or 5-day-old pupae exposed to 50° F. for 1 or 2 weeks produced few eggs and a high proportion were inviable. Adults from 6-day-old pupae exposed to 50° F. for 1 or 2 weeks produced as many eggs as moths from pupae held at room temperatures and viability was comparable.

6. Cabbage Looper Population Density and Migration Studies. Cabbage looper moth catches in light traps in cultivated vegetable growing areas at Riverside, Calif., increased gradually from approximately .05 moths per trap per night in early March to approximately 2.8 moths per trap per night in June. About equal numbers of each sex were caught. Dyed moths were recaptured at 1/4 and 1/2 mile distances from the release point. Approximately .1% of the released moths were recaptured during the period from April 23 to June 30.

7. Caterpillar Pests of Leafy Vegetables in Arizona. Continued black light studies of the flight habits and abundance of the cabbage looper, alfalfa looper, beet armyworm, yellow-striped armyworm, corn earworm, and granulate cutworm in the cultivated areas in the Salt River Valley and in adjacent desert areas indicate that desert areas are not contributing appreciable numbers of moths of any of these destructive caterpillars to the cultivated areas. Large numbers of the insects develop in the cultivated areas and fly into the desert areas during population peaks in August and September. Since the desert is dry at this time these flights are chiefly suicidal. However, they perpetuate the species in outlying and semi-isolated areas. Numbers of these insects were very low during winter months. Numbers of looper adults increased in May and again in July, reached a maximum in August and September, and decreased to a minimum in November. Corn earworm and yellow-striped armyworm moths also reached population peaks in August and September. Beet armyworm moths were far more numerous than any of the other species. All of these insects are important to agriculture in the Salt River Valley. The fall crop of lettuce is planted about the time the beet armyworm, yellow-striped armyworm, and cabbage looper adults are most abundant. Plant stands would be completely destroyed without the use of insecticides. Control of these insects is also necessary on other vegetable crops as well as on sugarbeets grown for seed and on cotton.

Release and recovery studies of reared marked cabbage looper and beet armyworm moths showed that anesthetization of moths with CO₂ and marking with lacquer on one forewing did not inhibit flight of the looper moths but may have caused slight damage to beet armyworm moths. Eighty-eight percent of marked looper moths released in large walk-in cages were recovered by traps compared to 86% of unmarked moths. Only 80% of marked

armyworm moths were recovered compared to 95% of unmarked moths. In the field, 6.9% of marked released looper moths were recovered by 8 black light traps surrounding the release point, 4.2% in 4 traps at 98 feet, and 2.7% in 4 traps at 184 feet. When the traps were moved out to 300 ft. and 440 ft. recoveries were 1.5% and 0.9% respectively.

B. Insecticidal and Cultural Control

1. Banded Cucumber Beetle. Of 61 experimental compounds compared in laboratory tests in South Carolina, 13 showed sufficient toxicity to justify further tests of their residual activity in soil.

2. Cabbage Looper. Laboratory tests in South Carolina of 54 experimental compounds disclosed 15 worthy of further testing in field plots. In field tests 8 experimental materials were effective but because of high toxicity either to warm-blooded animals or to cabbage foliage, none was satisfactory.

3. Pickleworm and Squash Vine Borer on Squash. Lindane tended to be most effective against pickleworm on summer squash in South Carolina, followed by the highest dosages of carbaryl and naled used. No difference was found between wettable powder and suspension concentrate (flowable) formulations of carbaryl.

4. Southern Potato Wireworm. In laboratory tests of 46 compounds in South Carolina, Stauffer B-10341, N-3727, and N-4446 and Shell Development 8803 were the only ones proving sufficiently toxic to larvae to warrant further testing. GS-4072 was as toxic as parathion and lindane as toxic as DDT to adults. When used at higher dosages, Bayer 38156 and 25141, Stauffer N-2790, mevinphos, and naled showed promise against larvae, and carbaryl, endosulfan, and Zectran against adults. Bayer 25141, Stauffer N-2788, a "slow-release" parathion, and Kepone (in a corn meal bait) showed promise against larvae in field tests. A "slow-release" parathion granular formulation gave 100% mortality of wireworms placed in treated soil 91 days after the application, as compared to 15% by conventional parathion granules.

5. Sweetpotato Insects. In a field test at Charleston, S.C., in which at least 6 species of insects damaged the roots, none of the insecticides tested reduced the number of injured roots by more than 32%. The currently recommended treatment, DDT at 20 pounds per acre, was generally most satisfactory.

Of 22 insecticide formulations field-tested in Louisiana for control of the banded cucumber beetle, only endosulfan gave promising results. No satisfactory method of control for this pest is available.

6. Mexican Bean Beetle. In Maryland field tests, Mexican bean beetle was controlled when granular phorate at 2 lb. per acre was placed beneath the seed. Four pounds per acre were required when the phorate was placed 2 inches to one side of the seed.

7. Dichlorvos. In Maryland, dichlorvos impregnated in polyurethane foam persisted for 7 months in killing drosophila adults. Dichlorvos was added to a polyurethane mixture at concentrations of 10% and 20% and poured into shallow receptacles. The mixture expanded into a foamy loaf-like mass that hardened in 1 to 2 hours. Flying drosophila adults not coming into contact with the surface became paralyzed within 10 minutes at the 20% strength and 2 hours at the 2% strength.

8. Beet Leafhopper on Beans. In small field plots of beans at Twin Falls, Idaho, dimethoate, mevinphos, and phorate gave promising results against the beet leafhopper, decreased the incidence of curly top, and increased the yield. In laboratory tests, each of these materials was more effective when mixed with sugar. As yet no satisfactory method of control is available.

9. Beet Leafhopper on Tomato. In a field plot experiment on tomatoes at Logandale, Nev., phorate granules at 2 pounds of phorate per acre--applied to the soil in February before planting in the seed bed--reduced the population of beet leafhoppers on weeds and tomato seedlings 50% by mid-April. Phorate granules at 2 pounds per acre applied as a topical treatment in mid-April reduced the beet leafhopper population and the incidence of curly top by 85%.

In an experiment at St. George, Utah, tomato transplants that received mevinphos emulsion in the plant hole at time of transplanting plus three topical applications of phorate granules at 2 pounds per acre had 8% curly top compared to 25% in untreated plots.

10. Corn Earworm in Sweet Corn. At Tifton, Ga., 7 new experimental insecticides gave equal or better control than the standard DDT emulsion spray. Trichlorfon also was effective. Dimethoate and dichlorvos were inferior.

At State College, Miss., good control of corn earworm was obtained with carbaryl at the rate of $1\frac{1}{2}$ pounds per acre and with Telodrin at 2 pounds per acre on sweet corn. Seven applications were made at every-other-day intervals beginning with first silk emergence.

C. Insecticide Residue Determinations

1. On Sweet Corn. At Tifton, Ga., residues of DDT were greater on silks and ear tips of sweet corn treated with DDT granules than on those treated with dusts or sprays at the same dosage of DDT. Emulsion sprays left the least residues. Variations in the quantities of DDT deposited by dust and granular treatments, however, were about twice the variation in the spray treatment.

An analytical method for Shell SD-8447 and its chlorine-containing hydrolysis product in sweet corn plants and ears was developed by pesticide chemists at Tifton, Ga., for use in field tests in 1964. The insecticide and the hydrolysis product chromatographed well in a stainless steel column

containing silicon grease on chromosorb W. Both products were completely recovered from corn plants and ears by blending with hexane-acetone and 95% was recovered with hexane alone. Hexane solutions of the concentrated extracts were cleaned in a counter current distribution apparatus.

2. On Sweetpotato. Over-tolerance residues were found by Beltsville, Md., chemists in sweetpotatoes from experimental plots in Louisiana where aldrin had been used at registered dosages. It was therefore necessary to discontinue recommendations for the use of aldrin on sweetpotato. Sweetpotatoes grown at Charleston, S.C., in soil treated with 1 lb. of Telodrin per acre prior to planting showed Telodrin residues ranging from 0.01 to 0.07 ppm at harvest.

3. On Cabbage in South Carolina. Analyses by ARS chemists in Maryland showed 0.04, 0.06, and 0.07 ppm of endrin on the usually marketed portion of cabbage sprayed with 0.4 lb./a. of endrin 33 days before harvest. Samples sprayed 41 days before harvest had 0.02, 0.02, and 0.03 ppm. On the basis of these data, USDA recommendations for the use of endrin on cabbage were discontinued.

4. On Cantaloups in Arizona. No phorate residues greater than 0.02 ppm (limit of accuracy of the analytical method) were found in mature cantaloup meats or rinds from a large-scale field plot that had been treated with 1 lb. of phorate per acre placed 1 inch under the seed at planting time.

5. On Lima Beans in Washington. Dry lima beans harvested 43 days after the last of three sprays of dimethoate at 3/4 pound per acre contained an average residue of 0.09 ppm of dimethoate. No measurable dimethoate residues were found in the dry pods or in the straw.

6. On Tomatoes in Maryland. Analysis of tomato fruits harvested at intervals after treatment with mist sprays of dichlorvos indicated that maximum residues of 8.7 ppm immediately after treatment decline to .1 ppm in 5 days and 0 ppm in 7 days.

7. On Carrots and Onions in Washington. Carrots and onions grown in soil treated the previous year with 5 lb. aldrin, 3 lb. dieldrin, or 20 lb. of DDT per acre contained significant but below-tolerance residues.

D. Biological Control

1. Sweetpotato Insects. Field and laboratory studies in South Carolina indicate that an undescribed nematode parasite of the genus Anphimermis may be an important factor in the natural control of the banded cucumber beetle in the South Atlantic Coastal areas. The general life history of the nematode was determined and a method of rearing developed. The nematode also parasitized the spotted cucumber beetle, the elongate flea beetle and the sweetpotato flea beetle.

The banded cucumber beetle was also highly susceptible in the larval stage to the nematode DD 136-bacterium complex. Studies in small soil cages in the field showed this complex remains effective longer in shaded soil than in unshaded. A greater number of infectious stage larvae of DD 136 were obtained from cadavers of cabbage loopers than from those of banded cucumber beetle larvae.

2. Cabbage Insects. In further field studies in South Carolina, weekly applications of a combination of a laboratory-cultured local strain of a nuclear polyhedrosis virus and a commercial flowable formulation of Bacillus thuringiensis were as effective against cabbage looper on cabbage in field tests during the fall of 1963 as was parathion. Similar use of the virus plus commercial flowable and wettable powder formulations of B. thuringiensis was more effective against the looper on cabbage than naled and mevinphos during the spring of 1964. When used alone, neither the virus at lower dosage nor the B. thuringiensis gave adequate protection. As used, the wettable powder was more effective than the flowable formulation.

Twenty-four insect pathogens were screened in California for effect on the corn earworm reared in the laboratory on artificial diet; 11 of them resulted in 80-100% mortality of larvae within 4 days after treatment.

E. Insect Sterility, Attractants, and Other New Approaches to Control

1. Sex Lure in Banded Cucumber Beetle and Spotted Cucumber Beetle. Studies in South Carolina of the sex attractant of the banded cucumber beetle indicated that traps baited with an extract of female abdomens and placed 20 feet apart in a soybean field caught at least 68% of the males in the field. Virgin females of the spotted cucumber beetle produce an olfactory male lure by the time they are 14 days old.

2. Sterilization of the Banded Cucumber Beetle. In laboratory studies in South Carolina, residues from 4% apholate spray on glass or plastic sterilized male cucumber beetles exposed to it for 15 minutes. All eggs laid by females mated to these males were infertile. Residues from 4% hemel and 4 and 8% hempa on plastic were ineffective.

3. Southern Potato Wireworm Bait. In exploratory field studies in South Carolina, a combination bait containing corn meal, soybean flour, wheat germ, and brewers yeast attracted more larvae than did soybean meal, corn meal, and tap water alone.

4. Sterilization of Cabbage Looper. In further studies in Riverside, Calif. the chemosterilants tepa, metepa, and apholate fed to cabbage looper moths induced variable degrees of sterility. Male moths that were fed tepa did not mate as frequently as untreated males. Tepa sprays, .5, 1, or 2%, induced complete sterility in male moths and metepa sprays were nearly as effective. Apholate sprays were less effective than either tepa or metepa.

Abnormal copulations in which males were unable to separate from females occurred more frequently when males were sprayed with high concentrations of tepa. In moths sprayed with tepa and dissected at various intervals, the testes showed no apparent visual differences and sperm packets were observed; ovarioles were distinctly deteriorated as compared to the ovarioles of untreated females.

Incorporation of various chemosterilants in larval feeding media resulted in high mortality. Chemosterilant treatment of pupae induced high degrees of sterility in emerged moths, but sterility was seldom complete.

5. Drosophila Attractants. Of 50 new materials tested as attractants for drosophila flies, none was superior to the Beltsville standard of 10% granulated sugar, 4% active dry yeast, 1% apple cider vinegar, and water.

6. Chemosterilant Baits Field Tested. In further studies on drosophila at Beltsville, Md., 16 chemosterilant bait stations per acre of tomatoes gave promising results in the control of drosophila in semi-isolated fields. Each bait station consisted of a gallon jar containing the standard bran-sugar-yeast-vinegar bait. The jar was sprayed inside and out with 2% of apholate. When distributed weekly for 6 weeks in replicated 1/4-acre tomato field plots at 4 per plot, 63% control of Drosophila melanogaster flies was obtained. Two-percent apholate sprayed on 4 hampers of ripe tomatoes in each plot was less effective than the apholate on the bait jars. Diazinon granules gave a maximum of 93% control at 1-pound of diazinon per acre-application, twice the dosage recommended.

Eggs from isolated females collected from apholate plots and eggs from laboratory-reared females mated to males collected from the same plots, revealed that a substantial number of each sex was sterile.

7. Mexican Bean Beetle. In Maryland, further studies on induced sterility of the Mexican bean beetle showed that females that mated with normal males in the fall were fertile in the spring whether or not they mated in the spring with sterile or fertile males.

F. Evaluation of Equipment for Insect Detection and Control

1. Insects Attacking Sweet Corn. Agricultural engineers at Tifton, Ga., have conducted experiments with new mechanical and physical methods for insect control. Preliminary work with oriented planting resulted in 61% of the corn ears growing perpendicular to the row, although there was no orientation of the foliage. Research was also continued on an electrostatic duster. Positively charged DDT and carbaryl dust gave better earworm control than negatively charged or uncharged dusts of the same insecticides. There was no significant difference in control obtained with negatively charged dusts or uncharged dusts. In another experiment a DDT emulsion spray gave better earworm control than any of the dust treatments. In the same experiment, negatively charged dust gave better control than positively charged or

uncharged dusts.

At Tifton, Ga., agricultural engineers and chemists used simulated corn ears made from filter paper to study nozzles, gallonage, and pressure. Effectiveness was measured by determining insecticide residues. Results indicate that there was an average of 19.1% more deposit on the front side than on the back side of the 2-inch tip of the ears when they were oriented 90° to the row. Ears oriented with the row received essentially the same deposit on both sides.

2. Improved Soil Sampling Methods. In sampling sweetpotato soils in South Carolina for larvae of cucumber beetles and flea beetles it was found that larvae could be removed from the soil much faster by introducing the water from below the screens rather than from above them. The washer developed for this purpose consists essentially of 3 trays with wire-screen bottoms, the screens being 8-mesh size in the top tray, 16-mesh in the middle and 32-mesh in the bottom. The trays nest inside each other and are mounted over a battery of 6 garden-hose nozzles.

3. Portable Vacuum Insect Collector. Such a collector was far superior to the standard sweep net for collecting leafhoppers on beans and related crops. Proportionally greater numbers of leafhopper nymphs were collected with the vacuum collector than with the standard sweep net at Yakima, Wash.

4. Work with Government-Owned Helicopter. In cooperation with the Agricultural Engineering Research Division at Forest Grove, Oreg., tests were initiated with the experimental helicopter equipped with spray booms that can be mounted at various positions, fore, center, and aft of the main rotor axis. Twenty-six multi-transect spray pattern tests were made--all with the boom mounted on the front ends of the skids, but with various nozzle arrangements and boom lengths and at different heights and speeds of flight. A symmetrical arrangement of 27 nozzles spaced 1 foot apart on a 26 ft. boom mounted on the front ends of the skids produced a swath of approximately 40 feet in width at the mean deposit rate, or above, when the helicopter was flown at 55-60 miles per hour at a flight elevation of 6-10 ft. Swaths of 47-56 ft. were obtained at flight elevations of 20-30 ft. at speeds of 28-32 mph. A characteristic area of lower deposit 5 to 10 feet to the right of the center line of flight was noted in all the spray patterns. A possible cause of this might be the air disturbance set up by the tail boom rotor.

5. Spray Pattern from Piper Pawnee PA-25-235 Airplane. In cooperation with the Agricultural Engineering Research Division a series of 70 spray pattern tests with this low-wing monoplane showed that an asymmetrical nozzle arrangement produced a satisfactorily uniform spray pattern over a 63 ft. swath when applied at 5-6 ft. elevations. Spray patterns of the first Pawnee tested had a zone of low spray deposit near the center. It was first thought this low deposit zone was caused by the fan-driven spray pump. However, later tests with a Pawnee equipped with a hydraulic-

driven spray pump proved the fan driven pump was not the cause but probably either the landing gear or the extended lip on the underside of the engine cowl.

G. Varietal Evaluation for Insect Resistance.

1. Sweet Corn. At West Lafayette, Ind., 28 yellow sweet corn inbreds were rated for earworm resistance. Of the 5 graded as resistant, the inbred (245 X 335) (5)1m-1m-3y-1 was the most resistant in 1963. It also had excellent resistance in 1962. From a group of 20 miscellaneous sweet corn inbreds, Tennessee inbred T24 was rated as the most resistant. The inbred has long, tight husks which probably account for its resistance. A group of 65 experimental yellow sweet corn hybrids contained 5 that rated resistant to highly resistant. The inbred parents of the 5 hybrids appear to be excellent source material for future earworm resistance studies.

Field studies at West Lafayette indicated that certain resistant sweet corn inbreds were resistant to the corn earworm due to husk characteristics. When the husks were opened and earworm larvae placed on the tip of the ears, no resistance was observed. Certain inbreds when used in single crosses seem to transmit resistance consistently even though the inbreds have not been rated as resistant. On the other hand, certain resistant inbreds seem to transmit susceptibility to their progeny. It was concluded that the best way to test the resistance or susceptibility of an inbred was to use the inbred in a number of single crosses and test the progeny. Apparently resistance or susceptibility may be masked in certain inbred lines of corn.

Corn earworms were reared in the laboratory at Tifton, Ga., on silks and kernels of sweet corn inbreds selected for their suspected influence on larval development. Nearly twice as many first instar larvae died after feeding on silks of M-119 or 380 as died when fed on P-39. Larvae survived on inbred 322 but the second year weight of the pupae was significantly lower than that of pupae taken from other inbreds.

Inbreds 166 and 259 continue to have the most transferable resistance for the earworm. Zapalote Chico, which has high resistance as an inbred due to an extremely tight silk channel, has produced susceptible crosses. Backcrossing with 81-1 and 471-U6 in hopes of producing a yellow hybrid with the earworm resistance and high quality of the white cross has shown promise. Hybrid 471-U6- X 81-1 has had a rating of high resistance in the Southern Sweet Corn Cooperative Trials but the hybrid seed is difficult to produce. The back crosses are much more vigorous and appreciably earlier than the parents. Male sterility has been incorporated into the white inbreds without significant loss of earworm resistance.

2. Sweetpotato. In field trials in South Carolina, sweetpotato breeding line L3-64 showed considerable resistance to injury by larvae of the southern potato wireworm, the white grub Plectris aliena, cucumber beetles, and at least one flea beetle. When freshly harvested roots of L3-64 and

comparable roots of Centennial, a commercial variety susceptible to injury by these insects, were offered to larvae of the wireworm, the white grub and the banded cucumber beetle in laboratory cages, each species showed a marked preference for Centennial. Banded cucumber beetle larvae reared on fresh roots of L3-64 had slower growth and lower survival than ones reared on roots of Centennial. The larvae showed little preference for cured roots of one variety over cured roots of the other. Uncured Centennial roots were much preferred to cured ones. Results of these laboratory tests indicate that a simple method of rating breeding lines of sweetpotatoes for this type of insect resistance can be developed.

In Louisiana breeding line seedling L3-64 showed a high degree of resistance to root damage by banded cucumber beetle larvae in 4 locations. Earlyport, Nugget, and L4-89 also were damaged less than Porto Rico.

3. Squash. In Washington preliminary observations of a series of clones derived from crosses of bush-type squash by T. E. Randall, Washington Experiment Station, indicate that some of these may be highly resistant to the two-spotted spider mite.

H. Insect Vectors of Diseases

1. Aphids and the Source of Lettuce Mosaic Virus. Aphids were trapped and seedling lettuce plants exposed to seven various ecological situations in the east end of the Salt River Valley of Arizona. The aphids acquired lettuce mosaic virus from weed hosts as well as cultivated plants. Virus-free seed is a partial solution to the lettuce mosaic problem, but these data show that the virus may be acquired from sources other than lettuce and transmitted to lettuce by migrant aphids.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Basic Biology, Physiology, and Nutrition

Cook, William C. 1964. Ecology of the pea aphid in the Blue Mountain area of Washington and Oregon. USDA Tech. Bull. 1287: 48 pp.

Henneberry, T. J. 1963. Effect of host plant condition and fertilization on two-spotted spider mite fecundity. J. Econ. Entomol. 56: 503-5.

Henneberry, T. J., and Shriver, D. 1964. Two-spotted spider mite feeding in bean leaf tissue of plants supplied various levels of nitrogen. J. Econ. Entomol. 57: 377-9.

Insecticidal and Cultural Control

Agric. Res. Serv. and Fed. Ext. Serv. 1964. Insecticide recommendations of the Entomology Research Division for the control of insects affecting crops, livestock, and households for 1964. USDA Agriculture Handbook No. 120 (revised).

- Henneberry, T. J. 1964. Aramite and Kelthane sprays for two-spotted spider mite control. *Agric. Chem.* 19: 43-4, 46, 131-2.
- Hills, Orin A., Coudriet, D. L., and Brubaker, R. W. 1964. Phorate treatments against the beet leafhopper on cantaloups for prevention of curly top. *J. Econ. Entomol.* 57: 85-9.
- Hills, Orin A., and Taylor, Edgar A. 1964. Cantaloup insects in the southwest. *USDA Leaflet No. 389*: 8 pp. (revised)
- Peay, Walter E., and Oliver, William N. 1964. Curly top prevention by vector control on snap beans grown for seed. *J. Econ. Entomol.* 57: 3-5.
- Reid, W. J., Jr., and Cuthbert, F. P., Jr. 1964. Control of caterpillars on commercial cabbage and other cole crops in the south. *USDA Farmers' Bulletin No. 2099*: 24 pp. (revised).
- Stone, M. W., and Prochaska, R. 1964. Field tests for the control of cabbage insects. *USDA ARS 33-92*, 11 pp.

Insecticide Residue Determinations

- Bowman, M. D., and Young, J. R. 1964. Persistence of Telodrin and DDT on sweet corn as determined by gas chromatography, *USDA ARS 33-93*: 7 pp.
- Maitlen, Jay C., Walker, K. C., and Westlake, W. E. 1963. An improved colorimetric method for determining endosulfan (Thiodan) residues in vegetables and beef fat. *J. Agric. Food Chem.* 11: 416-8.

Biological Control

- Creighton, C. S., Cuthbert, F. P., Jr., and Reid, W. J., Jr. 1964. Evaluation of Bacillus thuringiensis var. thuringiensis Berliner in control of caterpillars on cabbage. *J. Insect Pathol.* 6: 102-10.

Insect Sterility, Attractants, and Other New Approaches to Control

- Cantwell, George E., and Henneberry, T. J. 1963. The effects of gamma radiation and apholate on the reproductive tissues of Drosophila melanogaster Meigen. *J. Insect Pathol.* 5: 251-64.
- Cuthbert, F. P., Jr., and Reid, W. J., Jr. 1964. Studies of sex attractant of banded cucumber beetle. *J. Econ. Entomol.* 57: 247-50.
- Henneberry, T. J., and McGovern, W. L. 1963. Some effects of gamma radiation on fertility of Drosophila melanogaster and viability of sperm after multiple matings of males. *J. Econ. Entomol.* 56: 819-22.
- Henneberry, T. J., and McGovern, W. L. 1963. Effects of gamma radiation on mating competitiveness and behavior of Drosophila melanogaster males. *J. Econ. Entomol.* 56: 739-41.
- Mason, Horatio C., Henneberry, T. J., and Gibson, H. C. 1963. Attractiveness of insecticide baits to adults of Drosophila melanogaster. *J. Econ. Entomol.* 56: 725-7.
- Mason, Horatio C. 1963. Baited traps for sampling drosophila populations in tomato field plots. *J. Econ. Entomol.* 56: 897-9.

Wave, H. E., Henneberry, T. J., and Mason, H. C. 1963. Fluorescent biological stains as markers for drosophila. J. Econ. Entomol. 56: 890-1.

Wave, H. E. 1964. Effect of bait-trap color on attractancy to Drosophila melanogaster. J. Econ. Entomol. 57: 295-6.

Evaluation of Equipment for Insect Detection and Control

Fulton, R. A., Smith, Floyd F., and Busbey, Ruth L. 1964. Respiratory devices for protection against certain pesticides. USDA ARS 33-76-1: 12 pp. (revised).

Winterfeld, R. G., Young, V. D., Deonier, C. E., and Getzendaner, C. W. 1963. Piper PA-25 Pawnee distribution patterns. USDA ARS 42-84: 8 pp.

Winterfeld, R. G., Young, V. D., Deonier, C. E., and Getzendaner, C. W. 1964. Distribution patterns with the Piper Pawnee. Agric. Aviation 6: 52-4.

Insect Vectors of Diseases

Coudriet, D. L., and Tuttle, D. M. 1963. Seasonal flights of insect vectors of several plant viruses in southern Arizona. J. Econ. Entomol. 56: 865-8.

PEST CONTROL TECHNIQUES AND EQUIPMENT
Agricultural Engineering Research Division, ARS

Problem. Many pests attack economic crops in the United States, resulting in billions of dollars of loss to the farmer each year. Plant diseases, weeds, insects, and nematodes are examples. Every method to control or eradicate any of these pests requires some type of equipment. Effectiveness of the equipment necessary may be essential to the success of the method which is attempted or recommended.

Thus, equipment to control a wide variety of pests on a wide variety of crops is required. This requirement is partially met by the sprayers, cultivators, dusters, and soil injection equipment now available. However, mechanical cultivation does not always produce satisfactory weed control, and it is time consuming and costly. It is believed that with sprayers and dusters now used, often no more than 10 to 20 percent of the chemical goes onto the plant. Methods of applying nematocides in the soil do not always result in uniform nematode control, and untreated soil below the treated zone, in untreated pockets, and at the soil surface, provide sources for quick reinfestation.

There is need for improved methods of much greater efficiency for applying pesticides to plants and the soil. This implies a need for considerable fundamental study of small particle behavior, of radically new methods of applying chemicals, and of the movement of liquid and gaseous chemicals in the soil. The sales of present equipment are not great enough, nor are the manufacturers large enough, to permit industry to make a very great investment for research in this field.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving agricultural engineers, physicists, and mathematicians engaged in both basic studies and the application of known principles to the solution of farmers' problems. Cooperation is with the State Agricultural Experiment Stations of the states mentioned, unless otherwise noted. At Wooster, Ohio, basic research is conducted on fundamental studies of aerosols and on various spray formation devices. Soil fumigation research also is conducted at Wooster, Ohio. Disease control research is also conducted at Wooster, Ohio. Pest control equipment research for vegetables is conducted at Forest Grove, Oregon.

The Federal scientific effort devoted to research in this area totals 14.4 professional man-years, of which 1.7 is devoted to basic studies in aerosols and spray formations, 1.0 to soil fumigation, 1.0 to insect and disease control by ground equipment in vegetables and other low-growing crops, and 0.9 to aircraft equipment for application of pesticides to vegetables and other low-growing crops.

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 2.7 man-years is devoted to this work on all crops; figures are not available for work on vegetables.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Basic Studies in Aerosols and Spray Formation.

1. Mathematical and experimental studies on the basic transport, spreading, and distribution processes for fine particles suspended in turbulent gases were continued at the Pioneering Research Laboratory on Physics of Fine Particles at Wooster, Ohio. An instrumentation system is under development for measuring the distribution of fluorescent-traced particles on deposition surfaces to facilitate the study of relations between deposit distribution and the turbulence producing it. A method of spectral analysis has been developed which appears to be applicable to the measurement of surface deposit, but which needs further study. The use of a tape recorder has made experimental procedure immeasurably easier than if one attempted to process the "live" signal directly. Additional work is being carried forward in the areas of heat and moisture diffusion in fine-particle starch doughs, and in electrical diffusion of clay suspensions.

B. Soil Fumigation.

1. Field treatments were made in cooperation with the Ohio Station in order to study and develop methods and equipment for applying chemicals to soil for the control of crop pests. A number of volatile materials are now available in pressurized cylinders or bottles similar to the containers used for oxygen, nitrogen and other compressed gases. By using an appropriate regulator, these materials are easily applied by the field cultivator equipment with injector blades. Applications of this type made for control of Verticillium in vegetable plantings gave substantial increases in yield but the materials do not give the desired control of this disease. Measurements made of cherry trees planted in soil treated with several different nematocides in 1957 and 1960 show increased twig growth and greater spread of branches than in untreated plantings.

Applications of herbicides by a rotary tiller type of applicator, operated with forward travel per blade cut ranging from 1.5 to 4.7 in., show best result with the short cut. The short cut is believed to give a better resultant mixing of non-volatile chemicals with the soil.

Latex, asphalt and wax emulsions were applied to soil as surface mulches. This had previously been found to increase plant growth including weeds. Several formulations including different herbicides were applied. Generally these formulations appeared to produce some seedling injury and reduction in stand in vegetables on which they were used.

C. Insect and Disease Control by Ground Equipment in Vegetables and Other Low-growing Crops.

1. Both hydraulic and air blast sprays were applied to sugar beets in cooperation with the Ohio Station and Northern Ohio Sugar Company. Hydraulic applications were designed to study seasonal timing of spray applications, effect of interval between applications, various copper and oil combinations, and control achieved by other fungicides. Results were obscured by dry weather which prevented disease development. For example, although seven sprays of a copper and oil fungicide, beginning July 16 and applied at 10-day intervals, gave the best disease control, the yield of beets and sugar was no better than five sprays applied at 15-day intervals or three sprays at 20-day intervals.

A series of seven different air blast sprays were applied to sugar beets at 10-day intervals. Variations included gallonage applied, swath width, fungicide used, and operating pressure. Dry weather permitted little development of *Cercospora* leaf spot infection in the beet foliage. All treatments, therefore, gave excellent control of this disease. Manzate and copper with oil applied at comparative rates, showed a slightly higher sugar yield in favor of the former. Copper analyses were made of deposit samples taken across a 100-ft. double swath sprayed from both sides. These show a higher center deposit at a 40 gal. per acre application rate, when compared to rates of 20 and 10 gal. per acre. Other sample analyses show deposit patterns are affected by size, number, and placement of nozzles and by wind velocity and direction.

Sprays were applied to sugar beets at another location to study the effect of supplemental oils in improving the fungicidal action of fixed-coppers. The experiments indicate that increasing quantity added or viscosity of the oil, within the limits studied, increased the adhesion of copper to this foliage.

Sprays were also applied to a mixed vegetable planting to study spray adhesion on various types of foliage (pubescent or glabrous). The effect of dew and rainfall was included in this study, but extreme dry weather interfered with this part of the experiment. The results suggest that smooth foliage should be sprayed more frequently and with a higher dosage than hairy foliage, to obtain comparable disease control.

D. Aircraft Equipment for Application of Pesticides to Vegetables and Other Low-growing Crops.

1. Major project activities in 1963 included the rebuilding of a Bell 47D1 helicopter which was obtained by transfer in 1962. Operations consisted of dismantling all major components, sandblasting, overhauling, inspecting for flaws, painting and rebuilding the entire unit. Spray equipment was designed, fabricated and fitted to the helicopter and will be used in the research investigations. In February and March of 1963, an aircraft

mechanic and machinist, and an aircraft pilot, attended schools for helicopter mechanics and pilot training, respectively.

A series of bait insecticidal sprays were applied with the Rawdon T-1 airplane to a crop of peas for the control of the pea weevil in canning peas. These applications were made near Woodburn, Oregon, in cooperation with the Entomology Research Division. The flight elevation was about 25 ft. and the swath spacing 50 ft. The bait sprays consisted of brown sugar mixed in water and endosulfan or malathion and applied at the rate of 4 gal. of formulation per acre. The object of the tests was to control the insect with a minimum amount of toxicant by use of an attractant bait. In one test area the results were inconclusive. In another area 84 to 93 percent control was obtained at 48 hrs. after the application. The tests showed that the bait spray will suppress the pea weevil population on canning peas although not 100 percent was obtained.

Assistance was given to the Forest Service in conducting exploratory spray distribution tests with a helicopter owned and operated by Evergreen Helicopters of McMinnville, Oregon. The results of these pattern studies were used by the Forest Service as a basis for a series of aerial pesticide application tests with helicopters to control the Western Hemlock looper in Pacific County, Washington.

A spray distribution test series was conducted in cooperation with the Piper Aircraft Corporation using a Piper Pawnee PA-25-235 furnished by the Company. These data showed that a reasonably uniform and satisfactory deposit pattern as well as swath width could be obtained with a low density application rate (1-3 gal. per acre) when an asymmetrical nozzle arrangement was used. A satisfactory deposit pattern was not obtained for the high density applications. Tests were discontinued when the aircraft was recalled by the Corporation because of other commitments. These high density tests will be continued as opportunity permits.

A limited number of tests were conducted with a Piper Pawnee PA-25-235 aircraft owned by Sam Whitney of Newberg, Oregon. This aircraft was equipped with a hydraulically driven spray pump instead of the externally mounted windmill type drive and external mounting used by Piper Aircraft. The change in pump mounting did not appear to affect the spray pattern being deposited.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Basic Studies in Aerosols and Spray Formation

Brazee, R. D. 1963. Analysis of a Particular Stochastic Differential Equation. USDA, ARS 42-76 series. November.

Brazee, R. D. 1963. Theoretical Aspects of Droplet Impact Measurements. USDA, ARS 42-77 series. November.

Brazee, R. D. 1963. Particle-Size Distributions in Brownian Motion. USDA, ARS 42-78 series. November.

Brazee, R. D., and Hall, G. E. 1963. An Application of Data Smoothing by an Analog Computer. USDA, ARS 42-79 series. November.

Brazee, R. D., and Hedden, O. K. 1963. Some Theoretical Aspects of Soil Fumigant Diffusion. USDA, ARS 42-80 series. November.

Soil Fumigation.

Wilson, J. D., Hedden, O. K., and Bailey, Carl. 1963. Soil Treatments and the Growing of Locust Seedlings. Ohio Agric. Expt. Sta. Res. Cir. 114, 31 pp.

Wilson, J. D., and Hedden, O. K. 1963. Soil Fungicides Reduce Verticillium Wilt Effect on Vegetable Yields. Ohio Farm and Home Research. 48(4): 54-55.

Insect and Disease Control by Ground Equipment in Vegetables and Other Low-growing Crops.

Wilson, J. D., and Irons, Frank. 1963. Experiments on the Control of Cercospora Leaf Spot of Sugar Beets at Fremont in 1963. Ohio Agric. Expt. Sta., Botany and Plant Pathology Mimeo. Series No. 44B.

Wilson, J. D., and Hedden, O. K. 1963. Effect of Spray Oils on the Deposition and Retention of a Fixed Copper Fungicide. Plant Disease Reporter. 47 (6): 564-567.

Wilson, J. D., and Hedden, O. K. 1963. Leaf Character as it Influences Spray Deposition and Adhesion. Plant Disease Reporter. 47 (8): 732-735.

Wilson, J. D., Hedden, O. K., and Slesman, J. P. 1963. Spray Droplet Size as Related to Disease and Insect Control on Row Crops. Ohio Agric. Expt. Sta. Research Bulletin 945, 50 pp.

Wilson, J. D., and Irons, Frank. 1963. Control of Cercospora Leaf Spot on Sugar Beets in Ohio. Ohio Agric. Expt. Sta., Unnumbered Mimeograph.

Aircraft Equipment for Application of Pesticides to Vegetables and Other Low-growing Crops.

Winterfeld, R. G., Young, V. D., Deonier, C. E., and Getzendaner, C. W. 1963. Piper PA-25 "Pawnee" Distribution Patterns. ARS 42-84. September.

ELECTROMAGNETIC AND ULTRASONIC ENERGY FOR INSECT CONTROL AND OTHER FARM USES

Agricultural Engineering Research Division, ARS

Problem. Electromagnetic radiation has many established farm uses but research indicates many other highly useful potential capabilities in farm production, such as killing insects harmful to stored grain without leaving residues. To minimize the use of possibly hazardous chemicals and their residues in food products as much as possible, there is need for widespread investigation of non-chemical pest control methods, such as study of insect response to all possible types of radiation and sound and exploitation of weak physical links in the life of particular insects. There is need for detecting or removing insects in food processing plants, including fruit flies in tomato canning plants, and larvae of the cabbage looper and imported cabbage worm that may be clinging to spinach leaves when delivered to the processing plant. Treatments also increase the percentage of germination for some seeds and would therefore enable the establishment of good stands with lower investments for seed.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program of basic and applied research involving agricultural and electrical engineers and physicists working cooperatively with USDA entomologists and with the Experiment Stations of eight States. Electrical and physical methods of vegetable insect control and light trap design are studied in Indiana, with financial assistance from the Indiana Electric Association through the Purdue University Experiment Station. Research on electromagnetic energy for conditioning seed to improve germination and emergence is carried on in Nebraska, Tennessee, and Washington. The Federal scientific effort in this area is approximately 1.1 professional man-years.

PROGRAM OF STATE EXPERIMENT STATIONS

Several of the States are engaged in programs of basic and applied research on the possible use of some of the various forms of electrical and physical energies as a means for improvement of the potential capabilities in farm production.

Investigations in progress, many of which are cooperative with the Department, involved the evaluation of the use of radiofrequency energy for treatment of grains to destroy insect infestation and treatment of seeds to improve their germination characteristics; exploration of the feasibility of using ultrasonics and electric shock to control rats, mice and birds; studies of the possibilities for a major advancement in the technology of small particle depositions through the application of electrostatic, thermal or other inertial forces; and use of light sources of various wavelengths for attracting and collecting insects which infest many of our economic crops.

A total of 2.0 professional man-years effort is devoted to this work.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Electric Traps for Insect Survey, Destruction and Control

1. Electric Traps for Vegetable Insects

Research on the use of light traps for controlling vegetable insects was continued at Lafayette, Indiana in cooperation with the Departments of Agricultural Engineering and Entomology of the Purdue University Agricultural Experiment Station. The work is partially supported by the Indiana Electric Association.

Experiments with garden plots were continued for the sixth consecutive season. Cucumbers and tomatoes were planted in sixteen 60-ft. by 60-ft. isolated plots. Twelve of the plots were equipped with one light trap. Three different types of light traps were included in the experiment. Four of the plots were not equipped with a light trap. The effectiveness of the traps and insecticide treatments was determined from plant damage, insect counts, and yields. Three different insecticide treatments were compared in the study namely, six applications of dieldrin at two-week intervals, the same six applications plus five additional weekly applications until time of flowering, and no insecticide.

Cucumber yield data showed that light traps operated throughout the season combined with limited insecticide applications afforded protection from striped and spotted cucumber beetles. The best protection was provided by fan-type traps equipped with 15-watt blacklight (BL) lamps. Next in order came the electrocutor-grid type traps equipped with 5 BL lamps and a 5 BL gravity type trap. Yield differences were significant for the three trap types and all provided highly significant protection compared to unlighted plots. Both types of insecticide applications were highly effective in increasing yields over unsprayed check plots, but yields for the two different insecticide treatments were not significantly different. In studies using two strips of cucumbers 60-ft. wide by 840-ft. long, light traps were not effective for controlling cucumber insect pests at distances greater than 125 feet from the traps.

Activity of striped and spotted cucumber beetles was studied in a free-flight laboratory under controlled environmental conditions. Earlier response findings for the striped cucumber beetle were verified. The spotted cucumber beetle was found to react similarly. Neither species was active at 60°F. while both fly and respond positively to blacklight or green stimuli at 70°F.

Tests using corn earworm adults in the free-flight laboratory indicate that attraction to an electrocutor grid, which used no lamps as attractants, was caused by pinpoint corona discharges or by electric arcing. Earworms flew as well at 52° as at 60° or 70°F. Data were taken during the late flight of earworms to determine the time of light to traps in environmental conditions as they exist in the field. During light flights earworms were collected

randomly during the early evening hours. During heavy flights the insects flew to the trap in greatest numbers from 11 p.m. to 5 a.m.

Twelve light traps with five 15-watt blacklight lamps each in a 16-acre field proved very effective in protecting tomatoes from the larvae of both the tomato and tobacco hornworms. The damage to foliage and fruit was negligible. The tomato fruitworm (*Heliothis zea*) had no opportunity to damage tomatoes, since the main flight of the adults did not occur until the last of September and early October.

Studies including vegetable insects will be continued and expanded to determine the feasibility of controlling tomato insects in commercial plantings.

The use of light traps as insect survey tools will be studied with emphasis on corn earworms and cereal leaf beetles. Trap designs will be evaluated in terms of catch effectiveness.

Added emphasis will be placed on studies of the basic responses of insects to electromagnetic radiation.

In cooperation with the Virginia Agricultural Experiment Station and the Virginia Truck Experiment Station, a fan-type insect trap was used to determine its effectiveness on the egg-laying habits of drosophila in a tomato field. Few fruit flies of the available population were trapped and no effect was noted on egg-laying patterns. During the previous year a significant number of flies were caught when a similar trap was operated at a tomato cannery. Limited work will be continued.

In the cooperative insect population control study with the Entomology research Division at Oxford, North Carolina, data collected on corn earworm moths indicated that the traps caused a definite reduction in the number of infested ears of corn up to a distance of 300 feet from the trap. A general depression of the population inside the 113-square-mile area was also noted. More work is anticipated on traps as related to this insect.

2. Radiofrequency Treatment of Vegetable Seed

Study of RF electrical treatment for improvement of vegetable seed germination was continued in cooperation with the Asgrow Seed Company Research Center, Twin Falls, Idaho. Accelerated germination of spinach seed discovered last year following RF treatment was noted again this year in one of two varieties tested.

RF treatment substantially increased germination in seed lots of garden peas and beans which contained hard seeds. Work will be continued on evaluation of RF treatments for improving vegetable seed germination.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Electric Traps for Vegetable Insects

Deay, H. O.; Hartsock, J. G. and Barrett, J. R. 1963. Results of the use of light traps to control cucumber beetles. Proc. of North Central Branch, Entomological Society of America. Vol. 28. pp. 37.

ELECTRIC AND SOLAR EQUIPMENT FOR ENVIRONMENTAL CONTROL
Agricultural Engineering Research Division, ARS

Problem. Current scientific and economic developments indicate that production of vegetables and flowers in the future may require complete control of soil, light, and atmospheric conditions. Engineering problems associated with the application of light to plants have increased in recent years with the need for growth rooms for research and commercial use of light for growing crops.

USDA AND COOPERATIVE PROGRAM

A new program at Beltsville has been established whereby engineers from the Agricultural Engineering Division cooperate with the Crops Division on basic studies of light and thermal environment and their relation to plants in growth chambers.

Equipment for the application of carbon dioxide to plants is under development at Pullman, Washington, in cooperation with the Departments of Agricultural Engineering and Horticulture of the Washington Agricultural Experiment Station. Performance characteristics of equipment are being studied for maintaining environment for conditioning potatoes for processing.

The Federal scientific effort devoted to research in this area totals 5.4 professional man-years, of which 1.8 are devoted to plant environment equipment.

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 5.0 man-years is devoted to work in this area; figures are not available for work on vegetable crops.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Plant and Product Environmental Equipment

1. Carbon Dioxide Control in Greenhouses

The study of the engineering problems involved in the measurement and control of the carbon dioxide concentration in an air-supported plastic greenhouse was continued at Pullman, Washington, in cooperation with the Agricultural Engineering and Horticulture Departments of the Washington Agricultural Experiment Station, Washington State University.

The control system tested during the previous winter growing season was used throughout this report year. This control system allowed automatic control of the carbon dioxide concentration in four greenhouses at any constant level between atmospheric and 2,000 parts per million (ppm). Two new control systems have been built and some testing conducted. Both of these systems

are designed to vary the carbon dioxide concentration with respect to the available light intensity. Crops of lettuce, radishes, stocks, carnations and okra were grown under controlled carbon dioxide concentration. The concentrations studied included atmospheric (about 300), 400, 800, 900, 1,200, 1,600, and 1,800 ppm. The yield (fresh weight of heads) of Bibb lettuce was doubled, or nearly doubled, when grown under increased carbon dioxide concentration of 900 and 1,800 ppm. Of equal significance was the observation that acceptable crops of lettuce could be produced at higher than optimum growing temperatures with increased carbon dioxide concentration. Radishes (Cherry Belle, White Icicle) exhibited a two- to four-fold increase in root weight and approximately a two-fold increase in root weight to top weight ratio. Stocks, a fast growing floral crop, produced a shorter, heavier, thicker stem, indicating a more rapid rate of carbohydrate accumulation. Carnations came into production approximately three weeks earlier, produced more total flowers and more flowers of a higher grade. Okra exhibited an increase in stem diameter, fresh weight, dry weight, leaf area, fresh weight per leaf area and dry weight per leaf area. For all of the crops and carbon dioxide concentrations studied during the year, production was increased, however, in some cases maximum production occurred at concentrations less than 1,800 ppm.

2. Plant Growth Equipment and Techniques

At Beltsville instrumentation is under development for use with a data logger for measuring humidity, light, air quality, air velocity and plant movement. In cooperation with Crops Research Division a far-red light source, a temperature gradient chamber, and a light-tight shutter for rapid light cycling were developed.

Experimentation continued through the year in a commercial growth chamber to determine effects of different lamps on the growth of beans. First experiments compared special commercial design fluorescent lamps to the standard cool white fluorescent lamps. After several experiments we found no increase in growth from the special lamps.

Experimentation then proceeded to compare fluorescent light alone and with incandescent light added. It was found that incandescent light definitely has an effect on increasing growth. The effect is complicated by other conditions such as ambient temperature, heating effect of incandescent light, the time after planting and duration of incandescent light. The greatest single effect so far determined occurs by having incandescent light on beans for four 16-hour periods with fluorescent light starting the 12th day after planting.

A commercial angle transducer has been adapted to measure plant growth, leaf movement, lateral stem movements or other plant movements. As small as .005 inch can be recorded on either a milliamp or milliwatt recorder. The signal can also be put into the data logger. Tests carried out with this sensor include growth and primary leaf and lateral stem movements of beans. Seed-

ling growth of dark germinated and light treated zinnia seedlings was recorded for various light treatments. Indications are that there is a pause or even a shrinkage of plant growth when lights are suddenly turned on. Many applications of this can be foreseen as a rapid means of detecting plant response to various treatments.

3. Environmental Equipment for Potato Conditioning

The quality of processed potatoes varies considerably depending upon potato varieties, cultural practices, growing conditions and environmental conditions in which the potatoes are stored. A study is in progress by other research workers to determine variety differences and the optimum storage conditions for each variety. Work in Minnesota is underway to determine the equipment requirements to produce the optimum storage environments. Four cold storage rooms are being used for the studies, two of them cooled by mechanical refrigeration. Initially a standard refrigeration unit was used. The 10° drop in air temperature upon passing through the evaporator coil resulted in frosting of the coil. This moisture originates from the potatoes and during a long storage period can reflect a considerable shrinkage loss. Experimental coils were then installed to reduce this moisture loss. The second coil with a large face area and one row of coils in place of four has been in operation during the present storage period. To provide the same quantity of cooling it was necessary to increase the air flow by $2\frac{1}{2}$ times. There has been no frosting of the coil but the effect of the higher air velocity on the potatoes is being observed.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Carbon Dioxide Control in Greenhouses

Pettibone, C. A.; Matson, W. E. and Ackley, W. B. 1964. Control of carbon dioxide in an air-supported plastic greenhouse. ARS 42-92. Jan. 8 pp.

II. NUTRITION, CONSUMER AND INDUSTRIAL USE RESEARCH

UTILIZATION RESEARCH AND DEVELOPMENT Eastern Utilization Research and Development Div., ARS

Problem. Vegetable growing occupies over 3 million acres, with a yearly farm value of a billion dollars. Utilization as processed rather than fresh vegetables provides a constant source of supply with less price fluctuation. Basic compositional research is needed to provide knowledge of the constituents responsible for color, flavor and texture of vegetables and the changes these constituents undergo during processing, storage, and distribution. There is also need for application of these results to developmental research on new products and new and improved processing technology. Consumer preference is shifting to "convenience" foods. An even greater emphasis on quickly prepared foods is evident in modern military feeding where high bulk density, nonrefrigerated, and rapidly rehydrating products are of primary importance.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program employing chemists and chemical engineers in basic and applied research on vegetable processing and products. The Federal work is conducted at Wyndmoor, Pennsylvania. The scientific effort assigned to this area totals 4.5 professional man-years and is currently engaged in research on new and improved products and processing technology.

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

State stations have a continuing long-term research effort devoted to vegetable processing and products. Research on the adaptability and evaluation of vegetable varieties for processing is a standard service to plant breeding programs. Before introduction of new varieties, processing yields and processing characteristics are determined. This type of research extends to consideration of the effects of various production variables on processed product quality. Effects of maturity at harvest, mechanical harvesting, fresh product characteristics, post-harvesting handling and storage are examples of problems under study. The degree of correlation or association between color and flavor in fresh and in processed items is always of major concern.

Chemical composition and physical properties are also related to product acceptance and quality. This research ranges from standard composition studies to basic studies of special components. For example, the noncellulosic constituents of plant cell walls are being investigated. The nitrogen compounds in mushrooms are determined and evaluated as a function of previous history of growth, handling and processing of mushrooms. A continuing analysis of the biochemical changes that occur in vegetables at the different stages of maturity is made. Other studies deal with determination of the antioxidant properties of chile and the antioxidant effects exerted in the various kinds of meats. Estimates of the metal complexes of chlorophyll derivatives in processed foods and their effect on the color of processed foods are made

through processing experiments conducted under controlled conditions of metal contamination in the laboratory or in commercial processing plants. The role of enzymes in chemical and physical changes in processed foods is studied through use of purified enzyme systems, substrates and reaction products.

In order to obtain a better understanding of the reasons for changes in flavors during processing and storage and for the development of off-flavors, a comprehensive program on flavors in processed foods is in progress. Heat-induced flavors; lipids in flavor, bitter flavor of carrots, and natural fresh flavors of vegetables are all under study.

Microbiological research extends from study of the natural flora found on fresh vegetables to studies of contaminants found in commercially processed foods. Methods for microbiological examination of foods are being developed. Physiological, morphological, and nutritional variation among important organisms are determined to facilitate control of the organism or essential understanding of the role of the organism in desirable or useful applications. Bacterial endospores receive much study. It is hoped that this work will lead to the improvement of present methods of sterilization and food preservation. The radioresistance of bacterial endospores and use of combined antibiotics and heat are carefully researched to provide information of use in developing new and improved procedures for canning vegetables. Food poisoning organisms are the object of continuing interest. The incidence of spoilage organisms, survival patterns, and means of control are being investigated. Studies on the effect of carbon dioxide inhibition of microbial growth are in progress. The microbiology of processed foods, for example--dehydrated foods, is another area of research activity.

New and improved vegetable processing technology is sought in studies of freeze-drying, brining, canning, dehydration, fermentation, hydro-cooling and controlled atmosphere methods. Basic studies deal with new techniques of soaking and preparation, enzyme inactivation and regeneration, fluid flow and heat transfer problems. Special attention is being given to development of high-temperature, short-time methods and the advantages of low-temperature handling of sterilized foods. A comprehensive study of the effects of controlled or modified atmosphere on the biochemical, physical and general quality characteristics of various vegetable products is in progress.

New product research with vegetables is directed toward development of "quick cooking" peas and beans; beet chips; Puerto Rican style soups; snack items; and new sauerkraut products. Methods of processing, product characteristics and storage stability are determined. Some pilot plant research is done, but basic principles relating to composition, quality and functional properties are emphasized. Product characteristics such as sweetness, concentration of individual sugars, rheological properties, softness, water absorption, color and pigment are related to organoleptic properties and consumer acceptability.

The total station scientific research effort devoted to vegetable processing and products is 46.4 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. New and improved dehydrated products

1. Quick-cooking dehydrated vegetable pieces. Dissemination of information and distribution of samples relative to development of explosion-puffed dehydrated vegetables has stimulated industry to evaluate the process. Quick-cooking carrot dice are being produced commercially.

B. New and improved processing technology

1. Equipment development for explosive-puffing. Improvements in locking, releasing and control devices for the new batch gun, combined with a higher surface to volume ratio to expedite heating of the charge, have been developed to shorten the operating cycle, thus increasing production. Increased production, as ultimately obtainable with continuous puffing equipment, will lower costs per unit and result in greater commercial adoption of the process.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

General

Ball, C. Olin, Joffe, Fred M., Stier, Elizabeth F. and Hayakawa, K. 1963. The role of temperature in retaining quality in canned foods. American Society of Heating, Refrigerating and Air-Conditioning Engineers, 5 (6), pp. 93-109.

New and Improved Dehydrated Products

Cording, J., Jr., Eskew, R. K., Sullivan, J. F., and Eisenhardt, N. H., 1963. Explosive puffing process produces quick-cooking dehydrated vegetables. Food Engineering, 35, (6), pp. 52-55.

Komanowsky, M., Eskew, R. K. and Cording, J., Jr. 1964. Pure pumpkin powder. Food Engineering, 36 (5), pp. 107-108.

UTILIZATION RESEARCH AND DEVELOPMENT
Southern Utilization Research and Development Div., ARS

Problem. Although extensive progress has been made in recent years in developing stable, attractive, and convenient to use vegetable products, new and improved processed products must be developed and means of stabilizing perishable vegetables provided to minimize the adverse effects of seasonable surpluses and unfavorable markets, and to provide an adequate supply of good food for a growing population. Product quality needs to be improved and processing cost reduced through the adaptation and application of the latest technological developments and nutritional findings. For example, a major problem of the cucumber industry, since most of the crop is brine-cured, is to improve the curing process so that no loss occurs in the value of the cucumber during the brine-curing and storage process and the cost of processing is reduced. As another example, a pre-cooked, dehydrated, sweetpotato product has been developed which has good shelf life, when sealed under an inert gas. It reconstitutes to a product having the characteristics of freshly cooked and pureed sweetpotatoes. Applied research on a pilot-plant scale is needed to obtain additional engineering and processing data applicable to commercial production of flakes from different varieties. Basic research is needed to improve the quality and storageability of the product. There is a continuing need in the use of vegetables for processing to investigate the characteristics of the raw material as these characteristics are affected by climate, soil, cultural practices, breeding and the like. Celery, already an important flavoring ingredient, could become much more important if the factors and constituents responsible for the intensity, variableness, and stability of its flavor could be controlled in processing, and processed products of improved flavor and convenience could be developed. Many vegetables grown in the Southern Region differ in their chemical and physical characteristics from the same crops grown in the more temperate regions; and several vegetable crops are grown almost exclusively in the Southern Region. More utilization research is needed to complement the Federal and State production research programs and to provide cooperation in the form of composition and processing studies.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving biochemists, organic chemists, microbiologists, food technologists, and chemical engineers engaged in both basic and applied utilization research studies on vegetables of the Southern Region to develop new or extended uses for these commodities.

Research to develop basic information on chemical composition and physical properties of vegetables, their products and byproducts, is conducted as a basis for efficient research in developing new and improved food products and processing technology. Emphasis at the present time is on investigations

of the flavor and aroma components in natural and pure culture fermented cucumber pickle products, carried out at the U. S. Food Fermentation Laboratory, Raleigh, North Carolina, to provide the basis for producing pickle products of greater consumer acceptability. The North Carolina and Michigan Agricultural Experiment Stations, and the Pickle Packers International, Inc., cooperate in this research.

In the field of new and improved food products by processing of vegetables, both basic and applied research are being carried out at New Orleans, Louisiana, to improve the stability of the flavor of precooked, dehydrated sweetpotato flakes packaged in air, and to improve the processability of uncured sweetpotatoes and their flake characteristics. These are two major problems still facing the new sweetpotato flake industry. Current research approaches involve evaluation of antioxidants and other additives for flavor stabilization, and investigation of enzymes in accelerating the curing of sweetpotatoes. Close cooperation is maintained with the Louisiana Agricultural Experiment Station, and industry and industry associations. Research is in progress at the U. S. Fruit and Vegetable Products Laboratory, Winter Haven, Florida, on the development of processed celery products of improved flavor and convenience. Research is also being conducted at the U. S. Fruit and Vegetable Products Laboratory, Weslaco, Texas, to develop new and improved processed products from southern grown vegetables other than sweetpotatoes and celery. The Texas Agricultural Experiment Station and industry associations provide raw materials of known history for this research.

Research on new and improved processing technology is conducted at New Orleans, Louisiana and at the U. S. Food Fermentation Laboratory, Raleigh, North Carolina. Pilot-plant investigations are being carried out at New Orleans to develop new and improved processing methods applicable to commercial manufacture of stable, precooked, dehydrated sweetpotato flakes from sweetpotatoes of different varieties and environmental history. Processing variables currently being investigated include the effect of variety, curing, type of cooking, drying conditions, and various food additives. Cooperation is maintained with the Marketing Economics Division, ERS, for the market evaluation of improved flake products, and with the Louisiana Agricultural Experiment Station, the Louisiana Sweetpotato Association, the Louisiana Sweetpotato Commission, and various industrial concerns. At Raleigh the objective of the research is to improve cucumber processing technology and the quality of the products. Current emphasis is on investigations of methods for the controlled fermentation of cucumbers by application of pure culture techniques to fermentation practices (including differential control of microbial species in natural fermentations by chemical and physical means) in order to reduce processing costs and improve product characteristics. A hydrolytic enzyme inhibitor extracted from sericea forage which has been under investigation for the prevention of softening of cucumber brine-stock during the curing process is now being isolated in quantity for investigation of its chemical properties. Cooperation is maintained with the North Carolina Agricultural Experiment Station. The Michigan State University (Department of Microbiology) is also cooperating by providing technical

assistance in the controlled fermentation studies. The Pickle Packers International, Inc. contributes support to the research and supplies raw material.

The Federal in-house scientific effort at the Southern Division devoted to research in this area totals 19.6 professional man-years. Of this total 2.2 is devoted to chemical composition and physical properties, 10.9 to new and improved food products, and 6.5 to new and improved processing technology.

PROGRAM OF STATE EXPERIMENT STATIONS

State stations have a continuing long-term research effort devoted to vegetable processing and products. Research on the adaptability and evaluation of vegetable varieties for processing is a standard service to plant breeding programs. Before introduction of new varieties, processing yields and processing characteristics are determined. This type of research extends to consideration of the effects of various production variables on processed product quality. Effects of maturity at harvest, mechanical harvesting, fresh product characteristics, post-harvesting handling and storage are examples of problems under study. The degree of correlation or association between color and flavor in fresh and in processed items is always of major concern.

Chemical composition and physical properties are also related to product acceptance and quality. This research ranges from standard composition studies to basic studies of special components. For example, the non-cellulosic constituents of plant cell walls are being investigated. The nitrogen compounds in mushrooms are determined and evaluated as a function of previous history of growth, handling and processing of mushrooms. A continuing analysis of the biochemical changes that occur in vegetables at the different stages of maturity is made. Other studies deal with determination of the antioxidant properties of chile and the antioxidant effects exerted in the various kinds of meats. Estimates of the metal complexes of chlorophyll derivatives in processed foods and their effect on the color of processed foods are made through processing experiments conducted under controlled conditions of metal contamination in the laboratory or in commercial processing plants. The role of enzymes in chemical and physical changes in processed foods is studied through use of purified enzyme systems, substrates and reaction products.

In order to obtain a better understanding of the reasons for changes in flavors during processing and storage and for the development of off-flavors, a comprehensive program on flavors in processed foods is in progress. Heat-induced flavors; lipids in flavor, bitter flavor of carrots, and natural fresh flavors of vegetables are all under study.

Microbiological research extends from study of the natural flora found on fresh vegetables to studies of contaminants found in commercially processed

foods. Methods for microbiological examination of foods are being developed. Physiological, morphological, and nutritional variation among important organisms are determined to facilitate control of the organism or essential understanding of the role of the organism in desirable or useful applications. Bacterial endospores receive much study. It is hoped that this work will lead to the improvement of present methods of sterilization and food preservation. The radioresistance of bacterial endospores and use of combined antibiotics and heat are carefully researched to provide information of use in developing new and improved procedures for canning vegetables. Food poisoning organisms are the object of continuing interest. The incidence of spoilage organisms, survival patterns, and means of control are being investigated. Studies on the effect of carbon dioxide inhibition of microbial growth are in progress. The microbiology of processed foods, for example--dehydrated foods, is another area of research activity.

New and improved vegetable processing technology is sought in studies of freeze-drying, brining, canning, dehydration, fermentation, hydro-cooling and controlled atmosphere methods. Basic studies deal with new techniques of soaking and preparation, enzyme inactivation and regeneration, fluid flow and heat transfer problems. Special attention is being given to development of high-temperature, short-time methods and the advantages of low-temperature handling of sterilized foods. A comprehensive study of the effects of controlled or modified atmosphere on the biochemical, physical and general quality characteristics of various vegetable products is in progress.

New product research with vegetables is directed toward development of "quick cooking" peas and beans; beet chips; Puerto Rican style soups; snack items; and new sauerkraut products. Methods of processing, product characteristics and storage stability are determined. Some pilot plant research is done, but basic principles relating to composition, quality and functional properties are emphasized. Product characteristics such as sweetness, concentration of individual sugars, rheological properties, softness, water absorption, color and pigment are related to organoleptic properties and consumer acceptability.

The total station scientific research effort devoted to vegetable processing and products is 46.4 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Identification and Characterization of Flavor and Aroma Components of Pickle Products. Basic information on the lipid and fatty acid composition of fresh cucumbers and on volatile flavor components after pure culture fermentation has been obtained in cooperation with the Michigan and North Carolina Agricultural Experiment Stations and the Pickle Packers International, Inc. Eight fatty acids (palmitic, stearic, myristoleic, linoleic,

linolenic, myristic, oleic, and palmitoleic) were found in all six sizes of Model variety pickling cucumbers analyzed (from 1/2" to 2-1/2" in diameter). The saturated acid, palmitic, as well as two unsaturated acids, linoleic and linolenic, represented almost 90% of the total acid content (=0.05% on a fresh wt. basis). The unsaturated acids have been shown by others to be responsible for bleaching and off-flavor of vegetables such as peas and lima beans. Initial gas chromatographic studies of the flavor components of pure culture pickle fermentations have revealed the presence of at least 6 carbonyl compounds in the brines. Three of these--acetaldehyde, acetone, and an unidentified carbonyl--were obtained from 3 common lactic species (L. plantarum, L. brevis, and P. cerevisiae). The remaining carbonyls--iso-butylaldehyde, 2-butanone, and iso-valeraldehyde--were found in fewer brines and generally comprised less than 10% of the total carbonyl content. Brines from 4 strains of L. brevis did not contain iso-butylaldehyde or 2-butanone. After extensive work on the development of new and complex techniques using gas chromatography, analyses were extended to 34 strains of the 3 bacteria. The results indicated that the primary flavor components resulted from the species used to accomplish the fermentation process rather than from the cucumber per se; consequently, flavor of the finished pickle product may be determined largely--if not entirely--by the bacterial species chosen. However, it will require an extensive screening of homofermentative bacteria to select those strains and species giving the most palatable flavor sensations. Also in progress are companion studies on the flavor components in vinegar prepared commercially by three pickling companies and sampled at various stages of manufacture and storage and in pickle products made with each company's vinegar. Further research will emphasize qualitative and quantitative analysis of the flavor components of pure culture and natural cucumber fermentations. (S3 5-21).

B. New and Improved Food Products

1. New and Improved Dehydrated Sweetpotato Products. Information has been obtained on the enzymatic treatment of uncured sweetpotatoes with a commercial amylase to facilitate processing and to improve the characteristics of precooked dehydrated sweetpotato flake products, and on the use of additives to stabilize the processed flakes. Continued evaluations of flakes prepared from uncured sweetpotatoes with commercial amylolytic enzymes used to bring about changes comparable to curing were encouraging. Only slight deterioration was noted after 9 months' storage of the flakes in nitrogen. Several variables were later shown to affect the susceptibility of raw roots to amylolysis: time lapse between digging and processing, time of harvesting, and climatic conditions during the harvesting season. When the process was modified with respect to water conditions and level and duration of enzyme treatment, flakes produced from uncured sweetpotatoes were comparable to those made from cured and stored roots, but after one month's storage in nitrogen the flavor of the former was unsatisfactory; however, this result may be associated with the environmental history of roots used. Selected additives (e.g., high maltose or dextrose corn sirups), antioxidants (e.g., butylated hydroxyanisole or butylated hydroxytoluene), and synergists

(e.g., citric acid or ethylenediamine tetraacetic acid), either alone or in combination, failed to further improve the stability of air-packaged flakes from cured and stored sweetpotatoes; however, flakes containing these additives retained acceptable flavor after 5 months' storage in nitrogen. Future work will be directed toward developing a practical method for the enzymatic treatment of uncured sweetpotatoes and toward stabilizing the flakes made from both cured and uncured sweetpotatoes when packaged in an atmosphere of air. (S3 5-19, S3 5-25).

2. Development of Processed Celery Products of Improved Flavor and Convenience. Dehydrated celery far superior to commercially available products has been produced through use of the "explosion puffing" technique and a more efficient, high velocity dehydrator. The procedure consists of blanching, freezing, thawing, partial dehydration to about 70% moisture, puffing at 30 pounds of pressure, and drying; in this process, the most important variables to control are moisture content before puffing and puffing pressure. The new technique has solved the problem of incomplete rehydration and fiber toughness characteristic of earlier products. Although flavor loss is still a major concern, this deficiency is being investigated, particularly with respect to use of powdered leaves and recovered essences as potential sources of flavor. A highly efficient means of recovering volatile essence from steam blanched celery has been found, but extraction of essence from the steam condensate presents a problem. At the present time adsorption onto charcoal and solvent desorption offers the most promising means for concentration of the essence. Concentrated celery juice has been produced with and without added essence. It has good potency and when mixed with other vegetable juices, its flavor is easily detectable in small concentrations. However, production of a powdered celery juice presently seems impracticable because of lack of solids in the concentrate. The research has been facilitated by the development of procedures for rapid moisture determinations during dehydration runs and for assay of total flavoring capacity of processed celery products. The dehydrated celery will be subjected to tests for storage stability and to evaluation by taste panels. Future research will be directed toward exploration of various aspects of flavor retention and flavor restoration. (S3 5-23).

3. Development of New and Improved Processed Products from Texas Vegetables. Research is continuing to improve food products processed from carrots, green beans, and tomatoes. Samples of precooked dehydrated carrot flakes packaged in an atmosphere of nitrogen and stored for 11 months at 0° and 68° F. have retained their good quality. However, a sensory evaluation of the flakes packaged in air was discontinued at the end of three months' storage because the flavor had deteriorated to the point of being repulsive. Before commercial production of carrot flakes becomes feasible, it will be necessary to find a method suitable for increasing flake density.

In research on bush green beans, a number of varieties and two strains grown at two locations in Texas are being evaluated for their overall respective processing characteristics.

Other investigations demonstrated that firming tomatoes by blanching them in a 2% solution of calcium chloride increased the percentage of whole tomatoes when they were canned. The drained weight of canned tomatoes that had been blanched in the calcium chloride solution increased about the same extent whether their skins had been pricked or not. Measurements of viscosity of canned juices of Chico, La Bonita, and Homestead tomatoes correlate directly with their respective ammonium oxalate soluble fraction, inversely with the percentage of water-soluble pectic substances, and not at all with total pectin substances or total solids. The relationships noted may be significant in explaining the high viscosity of the canned juice of the Chico in comparison with La Bonita and Homestead. Whether size and shape of cellular particles also influence viscosity remains to be determined. Investigation of the effects of pectic substances on the processing characteristics of tomato varieties is continuing. (S3 5-22).

C. New and Improved Processing Technology

1. Development of Processing Methods Applicable to Commercial Production of Dehydrated Sweetpotato Products. Precooked, dehydrated sweetpotato flakes processed at SU from east-coast-grown Nemagold and Oklamor variety sweetpotatoes were evaluated by the Commonwealth of Virginia and rated "good." During periodic taste tests at SU, the product retained its flavor as long as 9 months. The tests are continuing. Results of this work have interested an industrial group in the Virginia area, which is looking into the possibilities of flake production.

Cooperative work with Milprint, Inc. and Continental Can Co. to determine the type of flexible package required for retail marketing of sweetpotato flakes has shown that a laminated pouch construction of polyethylene, foil, polyethylene, and paper or cellophane (inner to outer layer) may be suitable. However, the desired 100% test results have not yet been attained. In cooperation with ERS, 1200 samples of flakes in each of three types of packages were evaluated in a retail market test; the order of consumer preference was glass jar, flexible pouch, and then metal can.

A new project is directed toward developing stable sweetpotato flakes from sweetpotatoes of different varieties and environmental history. Numerous variables for the processing phase of enzymatic treatment of uncured Goldrush sweetpotatoes have been investigated to obtain the best flakes from this variety. Enzyme treatment before cooking resulted in a flake product that was not as good as that obtained by treatment after cooking. On the basis of current information, curing of sweetpotatoes to achieve best flake production appears to include treatment at 85° F. and 85% relative humidity for 10-14 days and storage for at least 5 or 6 weeks at about 60° F. The effect of drying variables on drying rate, bulk density, and quality of flakes was established. The maximum drying rate was found to be attained at the minimum retention time and minimum roll spacing that would produce an apparently uniform sheet along the width of the rolls. Initial tests with other varieties indicated that the processing characteristics

of Georgia Red were comparable to those of cured Goldrush but that the taste of the former was inferior; and that enzyme-treated cured Centennials processed as well as untreated cured Goldrush and had a good bulk density and a taste rated fair. Evaluation of stored sweetpotato flakes indicated that cultural practices and environmental and curing conditions have a greater effect on flake stability than do processing conditions.

Continued research on the processing of stable sweetpotato flakes has permitted SU to provide considerable technical information to two additional companies planning commercial production of the flakes. One company has installed flaking equipment and conducted test runs for the production of flakes, whereas the other plans to install a flake plant for operation during the 1964-65 season. Work to improve processing conditions and to utilize different varieties of sweetpotatoes will continue, as will cooperation with interested industrial organizations. (S3 5-19, S3 5-25).

2. Investigations to Improve Quality and Reduce Cost of Processed Cucumber Products. Recent research on pure culture pickle fermentations has brought the process closer to a practical, commercial basis. A continuous heat-shocking process for ridding the cucumbers of vegetative, asporogenous microorganisms prior to inoculation with lactic cultures was developed and successfully used in cooperating commercial plants as a step in the overall pure culture fermentation process. Preliminary results indicated that vacuum dried lactic cultures prepared in granule form by a major pharmaceutical company were not as satisfactory as either freeze-dried or broth cultures for initiating pure culture fermentations in heat-shocked cucumbers.

Recent evaluation of pure culture dill pickles 18 months old placed them at the top of the "good" category, equivalent to the rating of samples evaluated after 3 and 7 months' storage. This is significant because long shelf life is considered a very important characteristic for pickles and many other food products. In the pure culture fermentation work, sectional differences in taste preference have become evident, southern areas preferring a product more acid than that liked in northern regions. It has also been shown that good quality, pure culture dills can be produced satisfactorily either in glass jars or in tin cans. Plans for a new project include improving the present process and scaling it up for pilot scale and commercial production. (S3 5-20).

In cooperation with plant breeders and industry, new cucumber varieties that had undergone brine curing were evaluated for color, shape, percent of cure, texture, absence of bloaters, and overall acceptability for commercial use. Fresh pack dill pickles made from several cucumber varieties were also tested. This continued assistance to cucumber breeders in the proper evaluation of their breeding material is essential to the development of better varieties for the pickling industry. (S3 5-22).

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Chemical Composition and Physical Properties

- Gold, Harvey J. and Wilson, Charles W. III. 1963. A colorimetric ester test as a measure of total flavor in celery. Proc. Florida State Hort. Soc. 76, pp. 240-242.
- Gold, Harvey J. and Wilson, Charles W. III. 1963. The volatile flavor substances of celery. J. Food Sci. 28, p. 484.

New and Improved Food Products

- Burelson, C. A. (Lower Rio Grande Valley Exp. Sta., Weslaco, Texas). Stephens, T. S. (SURDD) and Longbrake, T. D. (Texas Agr. Ext. Service, Weslaco, Texas). 1963. Effects of different fertilizer treatments on the yield and processing quality of Pearlgreen variety green beans. Texas Agr. Exp. Sta. Progr. Rept. No. 2278, 4 pp.
- Deobald, H. J. and McLemore, T. A. 1964. The effect of temperature, anti-oxidant, and oxygen on the stability of precooked dehydrated sweetpotato flakes. Food Technol. 18, pp. 739-742.
- Stephens, Thomas S. and Griffiths, Francis P. 1963. Tenderometer values used to estimate can-fill for canning of California Blackeye No. 5 variety of southern peas. J. Rio Grande Valley Hort. Soc. 17, pp. 158-169.

General

- Gold, Harvey J. 1964. General application of near-infrared moisture analysis to fruit and vegetable materials. Food Technol. 18, pp. 586-587.

UTILIZATION RESEARCH AND DEVELOPMENT

Western Utilization Research and Development Div., ARS

Problem. Vegetable crops, in general, are perishable and seasonal and thus, are subject to supply and price fluctuations to the disadvantage of the agricultural economy. In order to expand markets and stabilize prices, new and improved processed products are needed that will be more desirable to the domestic and foreign consumer from the standpoint of quality, convenience, stability, nutritive value, safety, and cost. The quality of processed vegetables and the economy of their processing have not improved rapidly enough to increase or even maintain the relative position of vegetables in the American diet, or to increase substantially their contribution to the export trade. The consumption of dry beans and certain other vegetables is limited by the fact that they cause flatulence.

New easy-to-prepare vegetable products are needed, particularly from such commodities as dry beans and peas, which now require hours to prepare. The severe heating required to sterilize low-acid foods, which include most vegetables, seriously impairs the quality of canned products. The stability of all kinds of processed vegetables needs to be improved so that quality and nutritive value will be better preserved during storage and distribution. The safety and effectiveness of new chemical additives, needed to improve the quality and stability of processed vegetables, must be established. Better methods of removing residues of agricultural chemicals from vegetables for processing are urgently needed, as are procedures for decontaminating vegetables exposed to radioactive fallout. Of vital importance is research to reduce the costs of processing in order that the farmer may receive a larger share of the consumer's dollar.

Applied research on these practical problems must be supported by a strong program of basic research on the chemical constituents of vegetables responsible for flavor, color, and texture; on the reactions these compounds undergo before, during, and after processing; on constituents having biological activity; on the microscopic structure of vegetables and vegetable products; and on the micro-organisms which cause spoilage or loss of quality in these products.

USDA AND COOPERATIVE PROGRAM

In the Western Utilization Research and Development Division, a broad program of basic research on vegetables and the application of science to new and improved products and processes is conducted at the Division headquarters at Albany, California, in field stations at Pasadena, California and Puyallup, Washington; by contract at Urbana, Illinois, East Lansing, Michigan, and Davis and Berkeley, California; by a grant at Urbana, Illinois, and by grants under P.L. 480 in Cambridge and Chipping-Campden, England. Fundamental studies are conducted on the chemistry of vegetable flavor and

vegetable pigments, the mechanism of heat resistance in bacterial spores, the composition of dry beans as related to cooking quality and flatulence-producing characteristics, the factors affecting deterioration of dehydrated vegetables, and the microbiology of raw vegetables for processing. Applied research is conducted to develop new and improved products to increase the utilization of vegetables including new, high quality concentrated and dehydrated products and products of improved convenience of use, processes for producing these, selection of improved processing varieties, and methods for removing radioactive fallout.

The Federal program of research in this area totals 38.6 professional man-years, including three scientists whose salaries are provided by the California Lima Bean Advisory Board operating under a State Marketing Order, the United States Brewers Association, and the National Association of Frozen Food Packers; and five contracts and grants equivalent to approximately 2.5 professional man-years per year. Of the total, 20.1 are assigned to investigations on chemical composition and physical properties and 18.5 to new and improved food products and processing technology. In addition, the Division sponsors three grants under Public Law 480 on basic research.

PROGRAM OF STATE EXPERIMENT STATIONS

State stations have a continuing long-term research effort devoted to vegetable processing and products. Research on the adaptability and evaluation of vegetable varieties for processing is a standard service to plant breeding programs. Before introduction of new varieties, processing yields and processing characteristics are determined. This type of research extends to consideration of the effects of various production variables on processed product quality. Effects of maturity at harvest, mechanical harvesting, fresh product characteristics, post-harvesting handling and storage are examples of problems under study. The degree of correlation or association between color and flavor in fresh and in processed items is always of major concern.

Chemical composition and physical properties are also related to product acceptance and quality. This research ranges from standard composition studies to basic studies of special components. For example, the non-cellulosic constituents of plant cell walls are being investigated. The nitrogen compounds in mushrooms are determined and evaluated as a function of previous history of growth, handling and processing of mushrooms. A continuing analysis of the biochemical changes that occur in vegetables at the different stages of maturity is made. Other studies deal with determination of the antioxidant properties of chile and the antioxidant effects exerted in the various kinds of meats. Estimates of the metal complexes of chlorophyll derivatives in processed foods and their effect on the color of processed foods are made through processing experiments conducted under controlled conditions of metal contamination in the laboratory or in commercial processing plants. The role of enzymes in chemical and physical changes in processed foods is studied through use of purified enzyme systems, substrates and reaction products.

In order to obtain a better understanding of the reasons for changes in flavors during processing and storage and for the development of off-flavors, a comprehensive program on flavors in processed foods is in progress. Heat-induced flavors; lipids in flavor, bitter flavor of carrots, and natural fresh flavors of vegetables are all under study.

Microbiological research extends from study of the natural flora found on fresh vegetables to studies of contaminants found in commercially processed foods. Methods for microbiological examination of foods are being developed. Physiological, morphological, and nutritional variation among important organisms are determined to facilitate control of the organism or essential understanding of the role of the organism in desirable or useful applications. Bacterial endospores receive much study. It is hoped that this work will lead to the improvement of present methods of sterilization and food preservation. The radioresistance of bacterial endospores and use of combined antibiotics and heat are carefully researched to provide information of use in developing new and improved procedures for canning vegetables. Food poisoning organisms are the object of continuing interest. The incidence of spoilage organisms, survival patterns, and means of control are being investigated. Studies on the effect of carbon dioxide inhibition of microbial growth are in progress. The microbiology of processed foods, for example--dehydrated foods, is another area of research activity.

New and improved vegetable processing technology is sought in studies of freeze-drying, brining, canning, dehydration, fermentation, hydro-cooling and controlled atmosphere methods. Basic studies deal with new techniques of soaking and preparation, enzyme inactivation and regeneration, fluid flow and heat transfer problems. Special attention is being given to development of high-temperature, short-time methods and the advantages of low-temperature handling of sterilized foods. A comprehensive study of the effects of controlled or modified atmosphere on the biochemical, physical and general quality characteristics of various vegetable products is in progress.

New product research with vegetables is directed toward development of "quick cooking" peas and beans; beet chips; Puerto Rican style soups; snack items; and new sauerkraut products. Methods of processing, product characteristics and storage stability are determined. Some pilot plant research is done, but basic principles relating to composition, quality and functional properties are emphasized. Product characteristics such as sweetness, concentration of individual sugars, rheological properties, softness, water absorption, color and pigment are related to organoleptic properties and consumer acceptability.

The total station scientific research effort devoted to vegetable processing and products is 46.4 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Vegetable Flavor Components. Basic research on vegetable flavor is continuing through the study of the chemistry of volatile components using highly sensitive laboratory equipment and through evaluation of the olfactory response to individual compounds and groups of isolated compounds from vegetables. Panels of judges are used to measure the most dilute concentration of pure compounds that can be detected. Threshold concentrations data are beginning to show how odor strength is related to molecular structure. For example, the odor strength of a series of straight-chain saturated and alpha-beta unsaturated aldehydes progressively increases as the chain length increases from five to ten carbon atoms. An important question was settled by the clear demonstration that compounds of these types when present in undetectably small concentrations can add with each other to contribute a detectable odor to a mixture. Such results support the contention, which has frequently been stated but heretofore not unequivocally proved, that very minute amounts of substances in foods can contribute to the total flavor response even though they cannot be individually detected subjectively and perhaps exist only as traces in the most refined gas-liquid chromatographic separation of volatile materials. A Department scientist has presented the basic concept that the molecular shape of a chemical compound dictates its odor. He described how seven basic odors correspond to five specifically shaped receptor sites on the olfactory nerve endings and two other as yet imperfectly defined receptors. This stereochemical theory of olfaction is being subjected to critical research evaluation. Linear dimensions, cross sectional areas, and volumes of molecular models were measured and the goodness-of-fit to the postulated olfactory receptor sites estimated. Twenty-one chemicals having fairly rigid molecules and a camphoraceous odor were tested and although very diverse chemically, they were found to be nearly identical in size and shape.

Research is conducted on the composition of peas in relation to canned pea flavor. This work has been supported in part by the National Canners Association, which provided the salary of a chemist assigned half time to the project. Investigations of compositional differences among fresh, frozen, and canned peas revealed much higher levels of volatile compounds in fresh peas than in the two processed products. The appearance of propionaldehyde and hexanal in the canned pea samples suggested their formation during the heat sterilization process. Organoleptic evaluations were conducted to ascertain the importance of various compounds isolated from peas and processed peas. Dimethylsulfide has a low olfactory threshold and appears to be a major contributor to the flavor of canned peas as well as other vegetable products. When methionine was heated in the presence of pectin, dimethylsulfide was generated. Methionine, an essential amino acid in human diet, and pectin are both present in peas and many other common foods. Panels rated peas to which the non-caloric sweetener, hexamic acid, had been added above peas with no additives. If its addition to canned

peas can be demonstrated further to improve flavor, the regulatory agencies should offer no objection to its addition on the basis of public safety.

Research on the volatile components of tomatoes and tomato products was initiated. Substantial quantities of methylsulfide were found to be produced during heating and cooking of tomatoes. Processed tomatoes are always heat-treated and the usual standard of tomato flavor is high-quality, single-strength tomato juice rather than the juice expressed from a fresh tomato. A large quantity of fresh tomatoes was processed in the laboratory to collect volatile components for compositional studies. Twenty-three alcohol and carbonyl compounds have already been identified but they represent only a small fraction of the total number of components present. The large quantities of free sulfur found in the volatile concentrate fraction suggest the presence of very reactive sulfur-containing precursors. The effect of heating on tomato juice was tested in two ways. Odor thresholds were determined and the products were analyzed for methyl sulfide. Presumptive evidence indicated that the aroma intensity of a tomato juice is related to its methyl sulfide content. This relationship will be more thoroughly investigated in the future.

Compositional research on the essential oils extracted from hops is supported by the United States Brewers' Association which has provided the salaries of two chemists. The long-range purpose of this project is (1) to isolate and characterize volatile components that may contribute to the flavor of hops and (2) to study the chemistry of such components. Organoleptic evaluations of various fractions of hop oil and of recombinations of individual volatile constituents closely simulate the original hop oil flavor. Continued use of the capillary gas-chromatography-mass-spectral method of analysis has identified components of the oxygenated fractions of hop oil. Nineteen previously unsuspected compounds have been added to the growing list of known volatile hop oil components. One of the newly identified components is a thio-ester. Thio-esters have not been found widely in natural products. Odor thresholds of the isolated components of hop oil are being determined. About 16 components have thresholds ranging from 0.8 parts per billion to 250 parts per billion. Such identification of the relative contribution of individual components to the aroma of hop oil should provide the basic tools for controlling quality and making more uniform and better hop products.

2. Nature of the Heat Resistance of Bacterial Spores. The extreme resistance of bacterial spores to heat demands processing that degrades flavor, color, texture, and nutritional quality of canned vegetables. Basic investigations of the nature of heat resistance exhibited by spores have continued and have already led to a process which in the laboratory allowed a 50% reduction in heat treatment to sterilize a vegetable product containing large inoculations of spores of B. stearothermophilus, B. subtilis, and Clostridium #3679 (these organisms are frequently used for testing adequacy of heat processes).

Improved laboratory techniques were developed to separate various spore samples and to prepare them for detailed chemical investigation. A new controlled dry rupture procedure is highly reproducible and permits a pre-selection of the degree of rupture. This process separated spore coats without chemical changes that would be induced by heat or moisture. Ultra-violet absorption spectra of dry spores and of separated spore coats revealed the presence of calcium or magnesium chelates of dipicolinic acid in five different species. The relatively large quantities of dipicolinic acid and calcium provoked considerable speculation. The findings reported here are good evidence that calcium and dipicolinic acid chelate together in the bacterial spore. Spore separation by density gradient was advanced by the synthesis of a series of new, water-soluble, neutral, lead chelates which provide solutions of variable, high density but low ionic strength. The technique will aid in preparative separation of spores and studies on the heterogeneity of spore populations. The dry rupture and the density gradient separation procedures should apply widely in biological research beyond the study of bacterial spores.

Studies on heat adaptation of bacterial spores led to the observation that resistance to heat can be irreversibly reduced by briefly creating acid conditions around the spores. Low-acid vegetables can be treated briefly by addition of acid and then neutralized prior to canning. The acid treatment cut in half the heating time necessary to sterilize canned food in the laboratory. To guarantee the general use of this development, application was filed for a Public Service Patent covering the procedure.

3. Composition of Dry Beans. A systematic approach to determining the factor or factors in beans responsible for human flatulence is conducted by selective extractions followed by dialysis and ion exchange separations of bean components and measurement of the response to separated fractions when ingested. By these procedures the major part of the active principle was cornered in a fraction making up only a few percent of the total solids of the original beans. The active component was found to be soluble in both 60% and 85% aqueous ethanol and of molecular weight low enough so that the molecules can pass through a cellulose dialysis membrane. The fact that the flatulence principle could be separated from protein, led to a laboratory-scale process for preparing a flatulence-free protein concentrate from dry beans that should be readily adaptable to commercial processes.

By informal cooperative experiments, exploration of the possible mechanisms responsible for flatulence in humans was conducted at the Oak Knoll Naval Hospital in Oakland, California. Preliminary measurement of peristaltic activity using telemetry and a swallowed pressure-sensitive radio transmitter, indicated no difference in peristalsis after eating beans. Confirmation of this finding would require exploration of other possible mechanisms. Informal cooperation with the Department of Nutrition, University of California at Berkeley, has provided preliminary information on the effect of increased ventilation due to heavy exercise on the pattern of hydrogen elimination in human breath and flatus.

Closely coordinated with the studies at Albany, California, is supporting research conducted by contract at the University of Illinois in Urbana. The Illinois workers tried to develop an electronic device for recording the volume of flatus passed by a human subject while fully ambulatory but technical difficulties forced abandonment of this approach. A very satisfactory alternative procedure was developed in which a rectal catheter connected to a soft plastic bag was used. Using a plastic bag to collect flatus rather than the gas-trapping train used for in-house work allows the subject greater freedom to conduct normal activities without interference. However, the periodic measurements by weighing the trap of the gas train and periodic measurements of composition provide detailed data very useful in interpreting experimental effects. For different specific investigations each method will be advantageous.

4. Cookability of Beans and Peas. Compositional studies, supported in part by the California Lima Bean Advisory Board, which provides the salaries of two scientists, are directed toward understanding the effect on cooking of qualitative and quantitative differences in the proteins of large Lima beans. Electrophoretic separation of individual protein components from dry and immature beans and from beans at various stages of germination and cooking revealed significant differences in proteins. These results imply strongly that the cookability of dry beans is related to shifting protein composition or by intermolecular bonding of proteins.

A basic investigation of compositional factors related to cookability of dry peas was conducted at the Fruit and Vegetable Canning and Quick Freezing Research Association Laboratories at Chipping-Campden, England, supported by a grant under P.L. 480. It was completed in June 1964. The investigators showed that the influence of phytate ions on texture of cooked peas is very small, despite earlier opinions and supporting data that calcium phytate complexing influenced cookability. Analysis of subcellular fractions extracted from dried peas established the distribution of various elements in different tissues. In high-quality peas of good cooking characteristics the calcium ions are predominantly associated with proteins of the cotyledon, whereas in hard peas the calcium ions are in insoluble forms and are concentrated in the cell walls. Methods for measuring binding constants for calcium-protein complexes were investigated.

5. Pharmacological Investigations of Dry Beans. Components of dried beans are under pharmacological investigation to seek information relating to intestinal distress caused by ingestion of cooked dry beans. One procedure with laboratory animals has been to inject suspect compounds or extracts into contiguous ligated intestinal segments, each having the same arterial count. Two substances included in a 60% ethanol extract of cooked beans were shown by direct observation to have a significant effect on the rat's small intestine. A buffered solution of S-methyl-L-cysteine was injected into one segment and an equal volume of buffer into the other. An hour later the ligated segments were excised and weighed. The experiment was repeated enough times to provide statistically significant data, indicating

that S-methyl-L-cysteine caused an increase in intestinal segment weight due to mucous production. Authentic S-methyl cysteine and a dialysate from extracted cooked beans which was indicated by chromatographic procedures to contain S-methyl-L-cysteine, both caused contraction of a smooth muscle preparation. Histamine also caused such a contraction. An antihistaminic drug (Benadryl) inhibited the contraction of the smooth muscle preparation, leading to the conclusion that a histamine-releasing mechanism of action could be ascribed to S-methyl-cysteine.

6. Vegetable Pigments. Investigations on vegetable pigments are conducted to provide basic knowledge that can ultimately be applied to improve color quality of processed vegetable products. Modified analytical procedures for chlorophyll and chlorophyll degradation products were developed, including a resin-column technique to separate purified pheophytins a and b and a simplified thin-layer chromatographic technique for separation of pigment degradation products. Work on the development of new analytical procedures in this area was concluded and the methods so far developed are being applied to study the effects of processing variables on frozen, dehydrated and canned green vegetables.

Research on chemical changes in carotenoid pigments that result from processing vegetables and storing the processed products was concluded at the Low Temperature Research Station in Cambridge, England where it was supported with P.L. 480 funds. The investigation centered on the oxidative breakdown of beta-carotene to give the highly odorous compound, beta-ionone, and included studies on freeze-dried carrots and the chemistry of model systems. When foods are dehydrated by accelerated freeze-drying and subsequently stored in air, carotenoids oxidize, yielding volatile substances similar to those produced from the carotenoids themselves in chemical model systems. Many vegetables will lose vitamin A precursors by oxidation and plants high in carotenoids, such as carrots, will also lose color and develop off flavor. In addition, beta-carotene oxidation yielded large amounts of non-volatile hydroperoxide-containing polymers which may be toxic. These results point to a need to prevent the oxidation of carotenoids of food products such as by the use of antioxidants and also the need for more research in this area.

7. Histological Studies of Vegetable Tissue. Basic studies on the visual microscopic appearance of frozen vegetables are conducted with support from the National Association of Frozen Food Packers, which supplies the salary of one scientist. Structural damage caused by blanching and freezing of green beans is being investigated. The rate of ice crystal formation controls the size of ice crystals, which in turn controls the structural damage in frozen green beans. Moderate or slow freezing rates caused breakage of cell walls and separation of cells from each other. Very rapid freezing of green beans in liquid nitrogen greatly reduced damage to the frozen product and improved its texture after cooking.

Histological studies to acquire basic information on the mechanism of moisture movement and water-tissue relationships in vegetables were initiated

at the University of California at Davis under contract. Several vegetables, including onions, carrots, green beans, celery, green bell peppers, and mushrooms were used in preliminary work. For determining moisture content in the range between 10 and 70%, the Fischer titration method was found to be the most promising. The vegetables were dehydrated in progressive steps and judged by taste panels after reconstitution. Bell peppers could be dried to about 12% moisture with acceptable texture on reconstitution. Celery could be reduced in moisture only to 67% before it lost acceptable crispness. The other vegetables ranged between these two extremes. A better understanding of the mechanism of water movement through vegetable tissue during dehydration and rehydration in these different vegetables should yield information leading to improved processing methods and better products.

B. New and Improved Food Products and Processing Technology

1. Dehydrated Vegetables. Pilot-plant investigations of the foam-mat drying process were advanced far enough to study application of a standard process to various food products. Processors are most interested in drying tomato solids and pure lemon juice. The color and flavor of foam-mat dried tomato powder deteriorates if it is not protected from oxygen or if the moisture content is not below 3%. The processing conditions under which juice is extracted from tomatoes and concentrated also influences the stability of foam-mat dried powder prepared from the concentrate. For example, tomato powder made from high-quality, canned single-strength tomato juice had substantially greater stability than powder made from commercial tomato paste. Studies were initiated to determine if proper application of sulfur dioxide would prevent or substantially mitigate the changes induced by heat during concentration of tomato juice.

Studies on the critical problem of product burn-on of heat transfer surfaces are continuing with experiments on use of protein-splitting enzymes to reduce one source of burned material. Attention will be given to the rotating steam coil vacuum evaporators, which are increasingly being used in tomato concentration, and to control systems useful in reducing "burn-on."

Commercial processors of dehydrated vegetables believe their markets could be very much expanded if it were known how to process and package products so that they would better retain their initial flavor and color. In years past research has been conducted on the effects of processing and storage variables on the loss of color and flavor and the appearance of off-flavors in dehydrated vegetables, including the green vegetables. However, recent improvements in laboratory equipment and techniques offer considerable promise in providing a more detailed understanding of such changes that could lead to improved dehydrated vegetables. Research in this area is being redirected towards studies of the chlorophyll deterioration during processing and storage of green vegetables, utilizing some of the newer techniques of measuring chlorophyll components and products of chlorophyll degradation. Gas-liquid chromatography is being used to measure changes in

volatile components as a result of processing and storage effects. Organoleptic evaluations will be used to seek correlations with the objective measurements of product deterioration.

2. Dry Bean Products. The inconvenience of cooking dry beans and peas is widely believed to deter their utilization. Means for improving the convenience of cooking dry beans are being investigated, supported in part by the California Lima Bean Advisory Board. Processing large dry Lima beans to reduce cooking time was materially advanced. The processed beans retain the appearance of the usual dry Limas, have no detectable flavor difference, but can be cooked in 15 to 20 minutes without previous soaking. Dry beans vary widely and the time needed to soften the seed coats may differ from the time needed to soften the cotyledons. Reagents used in the process include specific edible chemicals for softening the seed coat and for softening the cotyledons. Occasional lots of dry beans require extremely long cooking. One lot of dry Lima beans that required 200 minutes or more to cook was altered by the new process to cook in less than 35 minutes. Stability studies indicate no serious regression in cooking characteristics during storage up to six months at room temperature when the moisture level remained between 8 and 12%. Studies at higher and lower moisture levels and at elevated temperatures have been initiated to determine the stability of the new quick-cooking Lima beans over a broader range.

We are also developing precooked legume powders. Such powders were prepared from a number of common varieties of dry beans, peas, and lentils, and each made into soup, snack dip, and other dishes to demonstrate versatility. A research contract was negotiated at Michigan State University to provide engineering data on a scale-up of the bean powder process as a preliminary step toward commercialization of the process.

Stability studies of unprocessed beans are also continuing. Large Lima, Sanilac, and Pinto beans at moisture contents of 10% or less did not change in cookability during two years' storage at 70° F. At higher moisture levels they became progressively slower to cook and the difference in cookability increased with increasing moisture content. At the 8% moisture level beans retained their cooking quality at 90° F. but cookability was increasingly impaired at higher moisture levels in 90° F. storage.

3. Frozen Vegetables. To supplement basic research on the histology of frozen vegetable tissue, preliminary investigations were conducted on the effects of liquid nitrogen freezing of green beans and corn. Frozen green beans with texture closely resembling that of unfrozen fresh green beans were prepared utilizing very rapid freezing that reduced breakage of cell walls and separation of cells. Lee-Kramer Shear Press measurements showed that beans frozen in liquid nitrogen were significantly firmer than those frozen in an air-blast at -20° F. Differences also existed between the air-blast frozen beans and beans frozen more slowly in a package, but the differences were very small. Organoleptic evaluations revealed that, within limits, the more rapid the freezing of green beans the firmer and more

acceptable is the frozen product. Corn that was blanched and frozen in nitrogen on the cob and then cut off was exceptionally sweet. However, after five months' storage at -10° F. an off-flavor developed.

Blanching studies with Brussels sprouts were concluded and specific recommendations were made for improving color retention in frozen sprouts, because Brussels sprouts are so large and variable in size that uniform blanching is difficult. Adequate blanching at the center of large Brussels sprouts frequently results in over-blanching the green outer leaves and this causes a loss of garden-fresh, bright green color. Preheating Brussels sprouts in water at 130° F. reduced substantially the time required for subsequent high temperature blanching. Blanching in water was found in laboratory studies to reduce blanching time requirements compared with blanching in steam at the same temperature. These findings were reported to the industry but commercial-scale operations and evaluations have not been conducted.

4. Processing Quality of Vegetables. Studies on processing characteristics of vegetable varieties are conducted cooperatively with the Washington State Agricultural Experiment Station. Evaluations are continuing on bush-type green beans which are needed to replace Blue Lake pole beans, which cannot be harvested mechanically. The bush Blue Lake varieties now available are approaching but are not equal to pole Blue Lakes grown in western Washington. The bush types are more variable in pod characteristics and breeding work will continue. Evaluations of processability will be conducted by Department scientists stationed at the Western Washington State Agricultural Experiment Station.

Experimental packs of all-white asparagus grown in central Washington indicate that good quality all-white canned asparagus can be produced there. The major commercial source of canned all-white asparagus has traditionally been in California and almost all of the product is exported to Europe. Increasing difficulties in obtaining stoop labor for California harvesting threatens to eliminate the white asparagus pack and continuation of this export trade may depend upon producing canned white asparagus in areas where harvest labor is less critical.

A new English hybrid Brussels sprout variety is being tested for commercial production in western Washington. The variety grown in this area had excellent flavor and color after processing.

5. Microbiology of Frozen Vegetables. Increasing pressure has been brought upon the frozen food industry by industry-enforced microbiological standards written into purchase agreements. Northwest frozen food packers are now willing cooperators in studies of plant sanitation and microbiology. Extensive sanitation programs exist at a number of the large freezing plants. These and the smaller plants with less adequate facilities or fewer trained personnel have cooperated informally with Department scientists to improve the general sanitary level in the industry. During the 1963 season, three

pea lines, four corn lines, three green bean lines, and one winter squash line were tested to determine the principal sources of bacterial contamination. For example, in regular cut bean lines, bacterial counts were lower than in french-cut bean lines. The difference could be traced to contamination from cutters and to the piles of sliced beans that are held back and used by check weighers to bring packages to the required weights. Such beans stand in reserve pans long enough for appreciable bacterial growth to occur. Regular cut beans, on the other hand, are filled with automatic equipment and do not require the individual check weighing of samples by workers on the processing line. Certain air cleaning equipment on pea lines was too complicated to be completely torn down for cleaning in the time usually allotted for cleanup and became a source of rather general contamination.

More basic studies on the growth of bacteria of types commonly isolated from frozen vegetables showed that reducing oxygen tension did not reduce the growth rate until the oxygen levels were less than 5%. Carbon dioxide was found to inhibit bacterial growth beyond the effect of the increase in acidity that goes with a carbon dioxide atmosphere. When systems were buffered so that no change occurred in pH, bacterial growth still was slowed by an increase in carbon dioxide concentration.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Chemical Composition and Physical Properties

- Alderton, Gordon, Thompson, P. A., and Snell, Neva. 1964. Heat adaptation and ion exchange in Bacillus Megaterium spores. Science 143(3601), pp. 141-143.
- Bailey, Glen F., Karp, Saima, and Sacks, L. E. 1964. Ultraviolet absorption of dry spores. Bact. Proc., pp. 36-37 (Abs. G125).
- Balls, A. K. and Ryan, C. A. 1963. Activities of directly and indirectly acetylated chymotrypsins. Proc. Natl. Acad. Sci. 50(3), pp. 448-453.
- Balls, A. K. and Ryan, C. A. 1964. Tryptic activation of acetylated chymotrypsinogen. Proc. Natl. Acad. Sci. 51(2), pp. 151-155.
- Burton, H. S., McWeeny, D. J. and Biltcliffe, D. O. 1963. Sulphur dioxide and ketose-amino reactions. Chem. & Indus. 17, pp. 693-695. ^{1/}
- Buttery, Ron G. and Teranishi, Roy. 1963. Food vapors analysis. Measurement of fat autoxidation and browning aldehydes in food vapors by direct vapor injection gas-liquid chromatography. J. Agr. & Food Chem. 11(6), pp. 504-507.

^{1/} Research supported by P.L. 480 funds.

- Buttery, Ron G., McFadden, W. H., Terahisui, K., Kealy, Mary P., and Mon, T. R. 1963. Constituents of hop oil. *Nature* 200(4905), pp. 435 and 436.
- Buttery, R. G., Lundin, R. E., McFadden, W. H., Jahnsen, V. J., and Kealy, Mary P. 1963. Volatile hop constituents: Identification of methyl dec-4-enoate and methyl deca-4,8-dienoate. *Chem. & Indus.* 51, pp. 1981 and 1982.
- Buttery, Ron G., Black, Dale R., Kealy, Mary P., and McFadden, William H. 1964. Volatile hop esters. *Nature* 202(4933), pp. 701 and 702.
- Carson, J. F. and Wong, F. F. 1963. A new colorimetric test for detecting sulfur-containing amino acids. *J. Chromatog.* 12(3), pp. 408 and 409.
- Carson, John F. and Wong, Francis F. 1963. The synthesis of cis-S-(prop-1-enyl)-L-cysteine. *Chem. & Indus.* 44, pp. 1764-1765.
- Carson, John. 1963. Separation and characteristics of onion components. Activities Report (Res. & Dev. Associates, Food & Container Inst., Inc., Natick, Mass.) 15(8), pp. 129-152.
- Guadagni, D. G., Buttery, Ron G., and Okano, S. 1963. Odor thresholds of some organic compounds associated with food flavors. *J. Sci. Food & Agr.* 14(10), pp. 761-765.
- Guadagni, D. G., Buttery, Ron G., Okano, S., and Burr, H. K. 1963. Additive effects of subthreshold concentrations of some organic compounds associated with food aromas. *Nature* 200(4913), pp. 1288 and 1289.
- Jahnsen, Vilhelm. 1963. Composition of hop oil. *J. Inst. Brewing* 69(6), pp. 460-466.
- Korytnyk, W. and Metzler, E. A. 1963. Composition of lipids of Lima beans and certain other beans. *J. Sci. Food & Agr.* 14(11), pp. 841-844.
- Matikkala, E. J. and Virtanen, Artturi I. 1963. New gamma-glutamylpeptides isolated from the seeds of chives (Allium Schoenoprasum). *Acta Chemica Scand.* 17(6), pp. 1799-1801. 1/
- McWeeny, D. J. and Burton, H. S. 1963. Some possible glucose-glycine browning intermediates and their reactions with sulphites. *J. Sci. Food Agr.* 14(5), pp. 291-302. 1/

1/ Research supported by P.L. 480 funds.

- Ralls, Jack W., Lundin, Robert E., and Bailey, Glen F. 1963. Preparation and thermal rearrangement of alkenyl 3-alkenyloxy-2-butenates. Catalysis of the aliphatic Claisen rearrangement of ammonium chloride. J. Org. Chem. 28(12), pp. 3521-6.
- Robb, D. A., Mapson, L. W., and Swain, T. 1964. Activation of the latent tyrosinase of broad bean. Nature 207, pp. 503, 504.
- Saarivirta, Maija and Virtanen, Artturi I. 1963. A method for estimating benzyl isothiocyanate, benzyl thiocyanate, and benzyl nitrile in the crushed, moistened seeds of Lepidium Sativum. Acta Chem. Scand. 17, pp. S74-S78. ^{1/}
- Sacks, L. E. Percell, Peter B., Thomas, Richard S., and Bailey, Glen F. 1964. Kinetics of dry rupture of bacterial spores in the presence of salt. J. Bacteriol. 87(4), pp. 952-960.
- Schwimmer, Sigmund. 1963. Alteration of the flavor of processed vegetables by enzyme preparations. J. Food Sci. 28(4), pp. 460-466.
- Schwimmer, Sigmund. 1964. L-cysteine sulfoxide lyase competition between enzyme and substrate for added pyridoxal phosphate. Biochim. et Biophys. Acta 81(2), pp. 377-385.
- Schwimmer, Sigmund. 1964. Specificity of L-cysteine sulfoxide lyase and partially competitive inhibition of S-alkyl-L-cysteines. J. Biol. Chem. 239(3), pp. 777-782.
- Spare, C. G. and Virtanen, Artturi I. 1963. On the lachrymatory factor in onion (Allium Cepa) vapours and its precursor. Acta Chem. Scand. 17(3), pp. 641-650. ^{1/}

New and Improved Food Products and Processing Technology

- Crean, D. E. C., and Haisman, D. R. 1963. A note on the slow rehydration of some dried peas. Hort. Res. 2(2), pp. 121-125. ^{1/}
- Elliott, R. Paul. 1963. Limitation of microbial levels in chilled and frozen foods. In "Microbiological Quality of Foods," Slanetz, L. W. et al., eds., Academic Press, New York, pp. 171-178.

^{1/} Research supported by P.L. 480 funds.

- Feinberg, Bernard, Schwimmer, Sigmund, Reeve, Roger, and Juilly, Marcel E. 1964. Vegetables. Chap. 13 in "Food Dehydration," Vol. 2, W. B. Van Arsdel and M. J. Copley, eds., Avi Publishing Company, Westport, Conn., pp. 222-302.
- Hart, M. R., Graham, R. P., Ginnette, L. F., and Morgan, A. I., Jr., 1963. Foams for foam-mat drying. Food Technol. 17(10), pp. 90-92.
- Joslyn, M. A. and Neumann, H. J. 1963. Peroxidase in frozen vegetables. J. Assoc. Off. Agr. Chem. 46(4), pp. 712-717.
- Morgan, A. I., Jr. Schaum-Schichttrocknung (Foam-mat drying). 1963. Dechema-Monographien Band 46, pp. 155-159.

NUTRITION AND CONSUMER USE RESEARCH

Consumer and Food Economics Research Division, ARS
Human Nutrition Research Division, ARS

Problem. The assortment and characteristics of foods available to consumers are constantly changing with the adoption of new production, processing, and marketing practices. Constantly changing also, as nutrition science advances, is our understanding of the nutritional needs of man and the manner in which these needs can best be met by food. To help meet the Department's responsibility to advise consumers on the quantity and variety of foods that will assure maximum benefit and satisfaction, research must continue on the nutritional requirements of persons of all age groups, and on the nutrient and other values of foods and on how to conserve or enhance these values in household preparation and processing. Periodic surveys of the kinds and amounts of foods consumed by different population groups and individuals also are essential for evaluation of the nutritional adequacy of diets and to give the guidance needed for effective programs of nutrition education. Information from such surveys provides assistance needed in market analyses for different commodities and in the development and evaluation of agricultural policies relating to food production, distribution and consumer use.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing program of research concerned with (1) nutritive and other consumer values of raw and processed foods as measured by chemical or physical means and by biologic response; (2) effects of household practices upon the nutritive values and inherent qualities of foods, and the development of principles and improved procedures for household food preparation, care, and preservation; (3) surveys of kinds, amounts, and costs of foods consumed by different population groups and the nutritional appraisal of diets and food supplies; and (4) development of guidance materials for nutrition programs.

The research is carried out by two divisions of the Agricultural Research Service -- the Human Nutrition and the Consumer and Food Economics Research Divisions. Most of the work is done at Beltsville and Hyattsville, Maryland; some is done under cooperative or contract arrangements with State Experiment Stations, universities, medical schools, and industry. The total Federal scientific effort devoted to research in these areas totals 63.3 man-years. It is estimated that approximately 5.2 man-years are concerned with studies related to vegetable products.

Human metabolic studies and the related exploratory and confirmatory studies with experimental animals and microorganisms concerned with defining human requirements for nutrients and foods are not reported on a commodity basis, though some of the work is applicable to this report. This basic nutrition research represents a total Federal effort of 26.7 professional man-years and is described in detail in the report of the Human Nutrition Research Division. Contract research supported by P.L. 480 funds related to nutritional value of vegetable protein is considered briefly in this report.

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

Nutrient Value of Food

Food composition and nutritive value is most frequently related to indigenous agricultural products. Specific and locally grown raw products are being extensively evaluated for essential nutrients, especially in Hawaii and Puerto Rico. Much work is related to changes induced by growing practices, processing and storage.

Certain raw products are being evaluated for their significant vitamin contribution to nutrition. The effect of production and processing practices on vitamin content continues as an area of interest. Additionally, research has been directed toward the study of vitamins in foodstuffs as affected by inhibitory and stimulatory factors.

The total program in this area includes 36 projects in 23 States and is comprised of 23.4 professional man-years.

Properties Related to Quality and Consumer Use of Food

In the area of food preparation, products are related to quality by some measure. Special measures characterize certain classes of products; i.e., vitamin assays, enzymatic activity, water binding capacity, and changes in structural tissues. Combinations of these are involved in the quality evaluation work reported.

The effect of pre-freezing treatments, as blanch and non-blanch of vegetables on the quality after quick-freeze, is under study. Comparative studies are being carried out on vegetables and fruits processed by freezing, canning and irradiation.

Food preparation research focusing on products for home use include: Microwave preparation of meats, fruits and vegetables, including the chemical alterations involved; and flavor characterization in frozen and stored products by means of vapor component identification.

Many of these same factors are under study in institutional preparation where the quantities involved impose special conditions. Heat penetration and internal temperature as related to quality, yield and culinary quality is an area of intensive study.

This portion of the program includes 52 projects in 21 States and is comprised of approximately 50.1 professional man-years. This is a partial report of the State Experiment Station programs in food science and includes work undertaken by home economics departments. For research on food and fiber utilization see reports of the Utilization Research and Development Divisions.

Food Consumption and Diet Appraisal

The State program in food consumption and dietary appraisal extends the work of the Department to other segments of the population or to geographic areas not separately identified in the nationwide studies. Currently 12 States are contributing to this program. One regional project is designed to yield information regarding food purchase and consumption patterns of families with preschool children. This group represents about one-fourth of the households in the North Central Region where the study is being made. Food habits will be evaluated in terms of the children's dietary needs. This research will provide information useful to both consumer and market interests. In the Western Region ongoing research on consumer satisfaction with selected vegetables and fruits is nearing completion.

The State program in this area totals 22.2 professional man-years.

PROGRESS--USDA AND COOPERATIVE PROGRAMS

A. Nutrient Value of Food

1. Tables of food composition. Research for the newly revised Agriculture Handbook No. 8 "Composition of Foods...raw, processed, prepared" has been supplemented by further research during the year and adapted to the needs of special projects.

Formulas and procedures that were used in calculating the nutritive values of 250 food items commonly prepared at home are being summarized in a publication for special users, particularly therapeutic dietitians and medical research workers. A table showing average adjustments for vitamin losses during cooking has been developed and will be included in the publication.

Selected data from revised Handbook No. 8 have been made available in decks of punched cards and magnetic tape for research workers. Arrangements have been made for the sale of the cards and the tape by a private data processing firm in Washington.

Tables for the Department of Defense have been prepared on the composition of 630 food items procured by the Defense Supply Agency for feeding military personnel. Values for the composition of foods developed for Handbook No. 8 and many additional values provided by the Department of Defense were used to develop the data needed for the numerous special food products meeting military specifications.

2. Vitamins. Analyses for the vitamin B₆ content and distribution in vegetables and in meats available to and as eaten by consumers, are in progress. Analyses of cereal foods, fruits, nuts, and cheeses are nearly completed and manuscripts are in progress.

A fluorometric procedure for the determination of pyridoxine as pyridoxal cyanohydrin was developed. The reactions were quantitatively reproducible over a range in concentration of 1 millimicrogram to 1 microgram per milliliter. Procedures for chemical assay for pyridoxal and pyridoxamine previously had been developed in this laboratory. Present studies are to adapt chemical procedures to analyze food extracts for the three forms of vitamin B₆. The procedures are expected to provide a more constantly reliable method for measuring this vitamin. Values from the chemical procedures are being compared with values obtained by microbiological determinations for vitamin B₆ in foods.

Development of coordinated procedures for B-vitamin analyses continued with emphasis on a rapid, stable chemical method for nicotinic acid.

3. Carbohydrates. Research is continuing on improving methods for analyses of individual sugars and applying them to various foods. Studies are concerned with extraction procedures, the determination of total and reducing sugars by conventional methods, and glucose and fructose by differential oxidation. Thin layer chromatography has been used for the separation and identification of some individual sugars from vegetable and fruit extracts.

B. Nutritional Evaluation of Vegetables

Vegetable proteins. Substantial progress continues on P.L. 480 projects designed to find practical economical sources of supplementary plant proteins, in order to provide staple supplies for refeeding malnourished populations, especially displaced masses, children, and elderly persons. Several of the most promising protein-rich mixtures of foods from vegetable sources reported last year (Israel) have been analyzed fully for minerals, vitamins, and amino acids, and further studies with laboratory animals have been made of their overall protein value. One product selected for preliminary feeding trials with young children was composed of one-half sesame flour, one-fourth soy flour, and one-fourth chickpeas. In the year ahead human metabolic studies will be used to compare this product with similar low-cost protein mixtures already in use in other countries (Central America, India, Far East).

Work was started on P.L. 480 studies in India to find other potential sources of good quality plant proteins for human nutrition in times of famine and dietary emergencies. Protein concentrates (40 - 60% protein) have been prepared from several types of easily extractable green leaves and their amino acid patterns determined. In the year ahead protein evaluation will be made using laboratory animals.

C. Properties Related to Quality and Consumer Use of Vegetables

1. Use of agricultural chemicals. Palatability evaluations of color, flavor, and texture were made for snap beans grown on untreated plots and on plots treated at the rate of two pounds per acre with Di-Syston (O,O-diethyl-S-2-(ethylthio) ethyl phosphorodithioate) or with phorate (O,O-diethyl-S-(ethylthio) methyl phosphorodithioate). Snap beans from Di-Syston-treated plots were rated by the panel as significantly more tender than snap beans from untreated plots or phorate-treated plots although no significant differences were found in readings by a shear instrument. Color difference meter readings showed snap beans from Di-Syston-treated plots were significantly darker, greener, and less yellow than snap beans from untreated plots and from phorate-treated plots. Snap beans from phorate-treated plots were significantly lighter in color than beans from the other two treatments and were significantly less green than beans from the untreated plots. No significant differences were found in panel scores for color. Snap beans from phorate-treated soil had significantly more off-flavor than beans from the untreated and Di-Syston-treated soils, but the off-flavor was considered "slight." Comparable samples of snap beans from the 1964 crop are under investigation. A report on the 2 years' work will be prepared.

2. Food distribution programs. Formulas and procedures were developed for using yellow corn grits in large and small quantity food service. Recommendations for use were made available to the families, schools, and institutions receiving yellow corn grits as part of the USDA food distribution program.

Guidelines for the use of toasted soy grits were developed for a pilot study in selected feeding operations of voluntary agencies in Latin America. This research was conducted in cooperation with AID, U. S. Department of State. The proportion of water to soy grits to use as a cereal was determined for a formula to provide 5 and 25 servings. Other formulas were developed for using soy grits in combination with bulgur wheat, rice, cornmeal, and dry beans. Also provided were serving suggestions and ideas for using soy grits in various food preparations.

Revision of the publication "Quantity Recipes for Type A School Lunches" (PA 631), was completed in cooperation with the Agricultural Marketing Service and the Fish and Wildlife Service, U. S. Department of Interior.

This recipe card file provides 324 quantity recipes or variations and other information needed in preparing Type A lunches in schools participating in the National School Lunch Program. Recommendations on preparing, storing, and handling a wide variety of vegetable, cereal, dairy, fruit, meat, and poultry products were updated to take into account recent research findings and technology. New recipes were tested and evaluated, and all formulas and yields were recalculated in line with the 1964 revision of PA-270, Food Buying Guide for Type A School Lunches.

D. Food Consumption and Diet Appraisal

1. Planning for proposed nationwide survey, households and individuals.

A nationwide survey of household food consumption and of the food intake of individuals is scheduled for 1965. Plans have been developed for a survey that would provide at least 6,000 household schedules and 10,000 individual schedules in the spring of the year with smaller household samples in each of the three succeeding seasons. The information on the week's food use to be obtained from each household is similar to that obtained in 1955, except that information on home baking practices will not be requested and information requested on home food production, home canning and home freezing will be reduced to allow interview time for questions on the food intake of individual members of households.

In preparation for the proposed first nationwide survey of the food intake of individuals, data obtained by recall on the 1-day intake of food from nearly 550 individuals of all ages in Washington, D. C. during June and July 1963, have been studied in relation to two controversial issues that concern collection of data. The survey findings indicate that for this group:

(1) The nonresponse rate on food intakes from individuals is not influenced by taking a schedule on household food consumption first in comparison to taking none, nor is it influenced by taking a schedule on food intakes from half in comparison to all individuals in the family; and (2) homemakers report the amounts of food eaten by family members in terms of their individual servings far more often than as proportions of household amounts. Tabulations of the Washington data also are useful as a pretest for tabulation of the nationwide survey.

2. Effects of food distribution programs on diets of needy families.

A survey of the food consumption of more than 800 households that were not participating in the food stamp program in St. Louis was made in May and June 1964 to determine the relation between usual family food expenditures and payments required for food coupons. Homemakers were asked also why their families did not participate in the program. Results of the analysis will guide the Department in revamping the St. Louis stamp program to make it more acceptable to eligible families and yet keep it within the limits of the program. Because of interest in the nutritional quality of food consumed by low-income families, an assessment may be made later of the dietary levels of these families. This is the sixth in a series of USDA food program surveys made in cooperation with the Marketing Research Division, ERS to assist the AMS to administer the food stamp and direct distribution programs.

3. Food consumption of the rural population in Spain (P.L. 480 research).
 A survey of the food consumption of the rural population in Spain has been initiated by the Spanish Ministry of Commerce under the cooperative sponsorship of the Economic Research Service and the Agricultural Research Service, using P.L. 480 funds. The study will provide information needed in appraising potential markets in Spain for U. S. farm products and should yield information useful to U. S. authorities on efficient ways of improving nutrition in low-income areas. The Spanish Ministry of Commerce expects to obtain much useful information on which to base a program for improving the diets of rural families, especially through better distribution of food. Information on food consumption, income levels, and related socio-economic characteristics has been obtained from about 1,200 rural families in 6 major regions of Spain. In summarizing the results, emphasis is being placed on (1) determining the nutritional shortages among these rural families at different income levels in the different regions, and (2) computing income elasticities for different foods as well as total food consumption.

4. Effect of socio-economic factors on intake of vitamin A and C rich foods.
 Under a cooperative agreement with the Minnesota Agricultural Experiment Station, intensive analyses of previously collected data indicate that: (1) Intake of vitamins A and C from food by 9- to 11-year-old Ohio children increased with family income, (2) at each income level a larger proportion of urban than farm children had food that provided recommended amounts of vitamins A and C, and (3) children whose food was supplemented by vitamin A and C concentrates in general did not need them as they were in "nutrition conscious" families that provided the children with foods that were high in these nutrients.

5. Nutritive value of national food supply. The nutritive content of the per capita food supply is calculated each year from estimates of quantities of foods consumed (retail weight basis) as developed by the Economic Research Service. This series, which begins with the year 1909, is being completely revised to incorporate newest estimates of per capita consumption, revised food composition data from Agriculture Handbook No. 8, and new information on the nutrients added to foods by enrichment and fortification.

A survey conducted by the Bureau of the Census for the Consumer and Food Economics Research Division has provided information for the years 1957-61, on quantities of enrichment ingredients supplied to processors to fortify flour and cereal products. Through this program about one-third more thiamine, one-fifth more iron and niacin and one-tenth more riboflavin are added to the Nation's diet than would be available if foods were not enriched.

For the first time, the enrichment survey was extended to include information on the quantities of ascorbic acid and vitamins A and D added to foods, thus furnishing a base line for future surveys. Currently the amount of ascorbic acid added to foods would be enough to increase the level in the per capita food supply by 5 percent. The contribution from synthetic vitamin A is 7 percent of which 6 percent is added through margarine. Vitamin D is not at present included in nutrient estimates.

6. Household practices in home freezer management. Recording forms and questionnaires for obtaining data on management practices of urban and rural home freezer owners were pretested and necessary revisions were made in preparation for data collection among households in Fort Wayne, Ind., and a nearby rural area. Information will be obtained in two seasons on the kinds, amounts, sources, prices, and turnover rates of frozen foods stored in the home. Such data will provide information needed to develop guidance materials for improved management of home freezers.

7. Development of food budgets and other basic data for food and nutrition programs. Interpretation of nutrition research findings and their application to practical problems has continued as part of an ongoing program to assist nutritionists, teachers, health workers, and other leaders concerned with applied nutrition programs or nutrition policies. Information developed under this program is provided to many groups both within and outside the Department working on practical food programs, on questions relating to nutritional requirements, food consumption, nutritional importance of specified foods, and on nutrition education. Increased emphasis has been given this year to opportunities for disseminating information to the public through TV and radio, the press, conferences, workshops, and the Department's Food and Home Fair.

Food budgets at different cost levels for individuals and families are priced quarterly for publication in Family Economics Review as a continuing service to welfare workers, extension agents, and others needing this information. For example, in June 1964, the cost of one week's food for a family of four including 2 school-aged children, was estimated to be \$24.40, \$32.80, and \$37.40, respectively, for the low-cost, moderate-cost, and liberal plans.

The food budgets published in Home Economics Research Report 20, "Family Food Plans and Food Costs," have been reexamined in the light of revisions in food composition data (Handbook 8, revised) and in recommended dietary allowances of the National Research Council. Some modification in food quantities was needed for certain individuals. This has necessitated revision of food plans and their presentation in technical and popular publications, including Agriculture Handbook 16, "Planning Food for Institutions," now being readied for publication. The "Food Purchasing Guide for Group Feeding," formerly a part of Agriculture Handbook 16, is in the final stages of editing for publication as a separate handbook.

All other existing guidance materials for nutrition programs were reviewed in light of the changes in recommended dietary allowances and in food composition data. Some publications have been revised; others will be updated for the next reprinting.

Nutrition Program News, a bimonthly periodical prepared for members of State nutrition committees and other community nutrition workers provides one channel for disseminating pertinent information about Federal programs and for reporting nutrition activities in the States. Issues this year included such diverse subjects as a report of the World Food Congress held in Washington, June 1963, "Labels on food products--the protection they give," and "Nutritional fitness for teenagers." Assistance to workers in nutrition programs has been provided also through consultation and program participation by staff nutritionists.

PUBLICATIONS--USDA AND COOPERATIVE RESEARCH

Nutrient Value

Watt, B. K., and Merrill, A. L. April 1964. Composition of Foods...raw, processed, prepared. Agriculture Handbook No. 8. Revised December 1963. 190 pp.

Watt, B. K. April 1964. Revising the Tables in "Agriculture Handbook No. 8." J. Am. Diet. Assn. 44(4): 261-263.

Leung, W. W., Pecot, R. K., and Watt, B. K. May 1964. Tables of the Composition of Foods for the Armed Forces. Department of Defense. Defense Supply Agency. 50 pp.

Consumer and Food Economics Research Division. Revised 1964. Nutritive Value of Foods. Home and Garden Bull. 72.

Consumer and Food Economics Research Division. 1963. Conserving the Nutritive Values in Foods. Home and Garden Bull. 90. 16 pp.

Camarra, R. T., Polansky, M. M., and Toepfer, E. W. 1963. Pyridoxine determined fluorometrically as pyridoxal cyanide compound. Paper presented at the annual meeting of the Assoc. of Off. Agric. Chemists, Washington, D. C.

Toepfer, E. W., Polansky, M. M., Richardson, L. R., and Wilkes, S. 1963. Comparison of vitamin B₆ values of selected food samples by bioassay and microbiological assay. J. Agric. and Food Chem. 11, pp. 523-525.

Murphy, E. W. 1963. Total diet study: B. Nutrient content. The authors M. J. Drutsch, D. Duffy, H. C. Pillsbury, and H. W. Loy, Food and Drug Administration, acknowledged the proximate composition data from Human Nutrition Research Division. J. Assoc. Off. Agric. Chemists 46, pp. 759-776.

Hivon, K. H., Hagan, S. N., and Wile, E. B. 1964. Preparation and analysis of some food fats and oils for fatty acid content of gas-liquid chromatography. J. Am. Oil Chemists Soc. 61, pp. 362-366.

Properties Related to Quality and Consumer Use

1963. Soy Grits. Agency for International Development, Department of State. Human Nutrition Research Division cooperating. Commodity Leaflet No. 8 Exp., 8 pp.

1964. Corn grits in family meals. Agricultural Marketing Service. Human Nutrition Research Division cooperating. AMS-256, 2 pp. (Processed).

1964. Corn grit recipes for schools and institutions. Agricultural Marketing Service. Human Nutrition Research Division cooperating. AMS-257, 3 pp. (Processed).

1964. Food buying guide for type A school lunches. Agricultural Marketing Service; Agricultural Research Service; and Fish and Wildlife Service, U. S. Department of Interior cooperating. PA-270, 75 pp.

1964. Green vegetables for good eating. Human Nutrition Research Division. Home and Garden Bulletin No. 41, 16 pp. (Rev.).

1964. Making pickles and relishes at home. Human Nutrition Research Division. Home and Garden Bulletin No. 92, 31 pp., illus.

Eisen, J. N. 1964. A note on orthogonal polynomials applied to treatment levels with unequal replications. Food Science 29(1): pp. 105-108.

Dawson, E. H., Brogdon, J. L., and McManus. S. 1963. Sensory testing of differences in taste. Part I. Methods. Food Technol. 17(9): pp. 45-48, 51, illus. Part II. Selection of panel members. Food Technol. 17(10): pp. 39-41, 43-44, illus.

Food Consumption and Diet Appraisal

Adelson, S. F., 1963. A 2-week vs. a 1-week Reference Period in Surveying Diets of Individuals. Abstract in Proceedings of Sixth International Congress on Nutrition, Edinburgh: p. 477.

Consumer and Food Economics Research Division. 1963. "The Nutritional Review." National Food Situation, No. 106, Outlook Issue, Nov.

Friend, B. 1963. Enrichment and Fortification of Foods, 1957-61. National Food Situation, No. 106, Nov.

Adelson, S. F., Delaney, I., Miller, C., and Noble, I. T. 1963. Discard of Edible Food in Households. Jour. Home Economics 55(8): 633-638.

Redstrom, R. A., Davenport, E. and Murray, J. 1963. Consumer Practices in the Handling and Storing of Commercially Frozen Foods, Two Cities, Two Seasons. Home Economics Research Report 23, 27 pp.

Consumer and Food Economics Research Division. Cost of 1 Week's Food at Home. Family Economics Review. Sept., Dec. 1963; April, June 1964.

Consumer and Food Economics Research Division. 1964. Family Food Budgeting...for Good Meals and Good Nutrition. Home and Garden Bull. 94.

Nutrition Program News (periodical, 5 issues): July-Aug. 1963; Sept.-Oct. 1963; Nov.-Dec. 1963; Jan.-Feb. 1964; Mar.-June 1964.

III. MARKETING AND ECONOMIC RESEARCH

MARKET QUALITY

Market Quality Research Division, ARS

Problem. Most fresh vegetables are highly perishable. Research is needed on sources and time of infection and physical and chemical methods for decay reduction. Basic studies are needed on cell metabolism as related to the causes and control of functional disorders and the nature of ripening and aging. Product quality as related to mechanical harvesting will need increasing study as will the effects of storage environment on keeping and eating quality. Safe and effective transportation can be accomplished only by continued research with transportation services, equipment, and methods as these affect ultimate quality of the product in the market. The increasing interest in liquid gases for transit refrigeration and atmosphere modification has posed a series of new problems relating to effects on the commodities from release of substantial amounts of nitrogen or carbon dioxide in the load compartments. Additional information is needed on objective indices for harvest maturity and quality factors as related to standardization and grading, and practical measurements for quality changes as the product moves through marketing channels.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing program of applied and basic research relating to quality measurement and protection of vegetables as they pass through marketing channels. The work is conducted by horticulturists, plant pathologists, plant physiologists, and food technologists.

Research is conducted at USDA laboratories in Beltsville, Md.; Fresno, Calif.; Miami, Fla.; Orlando, Fla.; Belle Mead, N. J.; Chicago, Ill.; and Harlingen, Tex., and at the North Carolina Agricultural Experiment Station, Raleigh, N. C.

Of the 15.7 federal professional man-years devoted to this program, 2.2 are devoted to objective measurement of quality, 3.0 to quality maintenance in handling and packaging, 0.5 to storage, 2.5 to transportation, 3.0 to postharvest physiology, 4.0 to postharvest disease control, and 0.5 to program leadership.

Work terminated during the period included: cause and control of black leaf speck of cabbage (MQ 2-43); and decay of Florida endive, escarole, cabbage and celery (MQ 2-47).

PROGRAM OF STATE EXPERIMENT STATIONS

Much of the genetic, breeding, variety, and cultural research with vegetable crops at the State stations has as its ultimate aim an increase in market quality of the product. This research, however, is reported elsewhere. Considering only that research which applies to vegetables in the handling and marketing channels, there are 101 projects in 36 States concerned with market quality of vegetables. These projects deal with many phases of vegetable handling and marketing including cleaning vegetables prior to storage; methods of quality separation of vegetables; effects of transit, storage, prepackaging, and retail handling treatments on market quality; packaging methods and materials; senescence and microbe-inhibiting chemicals; hydrocooling; optimum storage environments; modified atmosphere storage; the effect of temperature on the ripening of vegetables; and the influence of storage environment on chemical and physical changes in vegetables.

The effect of handling and marketing treatments on the market quality of vegetables is determined by chemical and organoleptic tests. There is continuing research on the development of objective methods for measuring quality and correlating these methods with market acceptance. One regional project dealing specifically with this area of research is NEM-30, Quality Maintenance, Measurement, and Control in the Marketing of Vegetables Including Potatoes.

Numerous projects in Plant Pathology contribute in part toward market quality of vegetables. Several of these are concerned directly with transit, storage, and market diseases which affect the quality of vegetables.

Total market quality research effort on vegetables at the State stations is approximately 32.9 professional man-years.

Insect Control. A discussion of the program of the State Experiment Stations in this area is presented under Area 13, Insect Control in Marketing Channels - cross commodity.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Objective measurement of quality

1. Sweetpotatoes. Data obtained on a number of varieties and selections grown in North Carolina, Virginia, Mississippi and Maryland on the use of the USDA Skin Color Fan show generally good agreement among the states for the various varieties. (MQ 3-50)

2. Tomatoes. A survey of tomato juice quality from the major tomato processing areas of the United States shows no correlation between centrifuge solids and total solids. The Tomato Color Index computed by the USDA tomato colorimeter, appears favorable for defining the color of processed juice. (MQ 3-15)

B. Quality maintenance in handling and packaging

1. Cauliflower. Cauliflower wrapped in sealed, unperforated film may be severely injured when the concentration of CO₂ within the wrapper exceeds about 8%. This injury, which causes discoloration, excessive softening, off-flavors and off-odors upon cooking, is not evident in raw cauliflower. Four $\frac{1}{4}$ -inch holes in the film wrapper in which the individual heads were wrapped prevented a build-up of carbon dioxide. (Exploratory Research)

2. Lettuce. A delay of 9 hours between harvest and precooling during a hot day reduced the market quality of untrimmed lettuce slightly after holding 7 days at 36° or 41° F. Time of cutting and holding temperature had a greater influence on market quality than delay in cooling. Lettuce cut at 3 p.m. and held at 41° had more pink rib and russet spotting, and was of lower quality than lettuce cut at 9 a.m. and handled similarly. However, when lettuce was held at 35°, time of cutting had no measurable effect on quality.

The market quality of field-wrapped, market-wrapped, and naked-pack lettuce from the same field was compared at Fresno and New York under actual and simulated shipping conditions of 7 or 8 days at 32°, 37°, or 41° F. followed by 4 days at 50° F. Differences in external appearance were small in most tests and were not consistently in favor of either wrapped or naked lettuce.

The quality of western head lettuce prepackaged with seven different plastic films in New York, was evaluated after a simulated wholesale (3-4 days at 40° F.) and retail period (2-3 days at 70° F.). In three tests conducted, 33 percent visible decay occurred in the shrink-film wrapped heads and 22 percent in heads packaged with the non-shrink films. The heat shrinkable films used were polystyrene, polyethylene and polyvinyl chloride and the non-heat shrinkable films tested were cellophane and stretchable polyvinyl chloride overwraps, and 2 types of polyethylene bags. (MQ 2-58)

3. Rhubarb. By removing the leaf blade and wrapping the stalks in polyethylene, the storage and shelf life of rhubarb was increased significantly and the weight and package size reduced by one-third. Wrapped, de-bladed whole stalks were usable after 4 weeks at 32° F. plus 1 day at 70°, or 2 weeks at 40° plus 1 day at 70°. The shelf life of 1-inch stalk pieces packaged in polyethylene bags was about $\frac{1}{2}$ that of whole stalks. This work will be completed upon preparation of the report. (MQ 2-61)

4. Vacuum Cooling. Cooling was found to be most efficient when the pressure is reduced to 7.5 mm. Hg. quickly and held near 4.0 mm. Careful control of pressure with effective gauges prevented freezing near the end of the cooling cycle. Time tables were prepared for several crops packed in various types of containers and plastic films. (MQ 2-80)

C. Quality maintenance in storage

1. Asparagus Plants. Asparagus crowns stored at 32° F. for 3 months before planting gave highest yields of cut spears over a 3-year period when the roots were trimmed to 8 inches before storage. Roots trimmed to 4 inches yielded slightly less than untrimmed crowns. Polyethylene-wrapped crowns planted directly from cold storage gave yields comparable to burlap-wrapped crowns but when held for 6 days at 60° before planting, burlap-wrapped crowns gave significantly higher yields. (MQ 2-89)

2. Onions. More physiological breakdown (translucent scale) was found in onions delayed 15 days or longer after curing before storage than in those stored immediately. The disorder occurred mainly in onions 3 inches or larger in diameter and in onions maturing at high temperatures. Shading of the bulbs during growth reduced breakdown. The disorder occurred in onions grown on both peat and mineral soils. This work will be completed upon preparation of the report. (MQ 2-56)

3. Sweetpotatoes. Storage losses of sweetpotatoes stored in palletized field boxes was 11% vs. 20% in tub-bottom bushel baskets stored in the conventional manner, a savings of nearly 25 cents per bushel. Cool air drawn into the top of storage rooms at 1 to 2 cfm per bushel of storage capacity during late fall and early spring maintained storage temperatures at desired levels and decreased the temperature gradient within the rooms. This system of overhead ventilation was superior to the currently used system of introducing outside air at floor level and exhausting air at the top of the rooms. (MQ 2-73)

4. Mushrooms. Fresh mushrooms held for 3 days at 59° F. in 0 or 1/4 percent O₂ without CO₂ had almost no enlargement of the pileus, elongation of the stipe, or change in color, whereas those held in air continued to grow, open up, and darken. A slight amount of oxygen (1%) was necessary to prevent off-flavors. Mushrooms sealed in polyethylene bags, that were either purged with nitrogen before sealing or sealed with air in them, produced atmospheres with about 1/2 percent O₂ and 9 to 12 percent CO₂ after 4 days at 50° F. These atmospheres were effective in slowing growth, but the nitrogen purging resulted in a brown water-soaked appearance. (Exploratory research)

D. Quality maintenance during transportation

1. Asparagus. Although soft rot development in all-green asparagus was generally negligible during simulated rail transit, CO₂ levels of 5 and 10% held soft rot to less than 0.5%. Flavor or appearance of the cooked spears was not affected by these CO₂ concentrations under simulated refrigerated transit. Carbon dioxide levels of 10 to 50%, with O₂ above 5% during simulated air transit times of 24 hours at 36°, 41° or 50° F. significantly reduced the development of soft rot at the cut end of the spears during subsequent holding for 7 days in air at these same temperatures. This

effect was still evident after 2 additional days in air at 59°. Soft rot at the tip end was not affected by this brief exposure to CO₂. Spears were injured by 50% CO₂ in most tests and by 20 and 30% in one test. (MQ 2-13)

2. Lettuce. Liquid nitrogen as a substitute for or a supplement to mechanical refrigeration of piggyback trailers was tested with lettuce shipped from California to Chicago. Transit temperatures in trailers using only liquid nitrogen as a refrigerant averaged 3 to 5 degrees F. warmer than mechanically refrigerated trailers, in summer shipments. At destination, temperatures were frequently 7 to 15 degrees higher in the nitrogen units. Temperatures in trailers in which the nitrogen was used only to supplement the mechanical refrigeration were similar to mechanical units without nitrogen. Modification of the atmosphere in the trailers was quite variable, ranging from normal oxygen levels of 20% to as low as 3.8%. Carbon dioxide concentrations at destination were 1 to 2%. Quality was similar in lettuce shipped by the two methods in tests made to date, except for russet spotting which was only about one-half as severe in lettuce from trailers using nitrogen as that from companion trailers without nitrogen. (MQ 2-84)

3. Vine-Ripened Tomatoes. Since vine-ripened tomatoes are often shipped with other vegetables that require more refrigeration than tomatoes, experiments were conducted at Beltsville to determine possible adverse effects on tomatoes when exposed to temperatures below 50° F. Color development of tomatoes harvested after some red color was visible was sharply retarded by holding at 45°, 40°, and 32° for periods up to 6 days. Color development resumed promptly after the fruits were removed to 70° and the tomatoes eventually attained about the same degree of red color as those held at 70° continuously. Chilling injury did not occur during 6 days' holding at the low temperatures but did develop after 10 days at 32°. The more mature the fruits were at harvest the less subject they were to chilling injury. This project will be completed upon preparation of the report. (MQ 2-23)

E. Postharvest physiology

1. Effects of Low Oxygen. Tests at Harlingen, Texas showed that quality of cauliflower after 30 days in test atmospheres plus 7 days in air at 36° F. was best when the heads were held in 0.5 to 1% oxygen with carbon dioxide allowed to accumulate to an average of 11%. The external appearance of lettuce was good after 42 days storage in a test atmosphere at 36° of 0.5 to 1.0% oxygen plus gradual carbon dioxide build-up to 7.5%. However, severe internal browning (CO₂ injury) developed. This was eliminated when the evolved carbon dioxide was absorbed with lime. However, lettuce from the CO₂ free atmospheres looked no better than lettuce stored in air at the same temperature. Okra, after 11 days in test atmospheres at 45°, had the best quality when held in 10% carbon dioxide and 11% oxygen.

At Beltsville, lettuce and celery held 6 weeks at 33° F. remained in better condition in an atmosphere of 1% oxygen and 99% nitrogen than in air at this temperature. Decay and discoloration of the butts of both commodities were reduced in 1% oxygen.

After 5 days at 33° F., respiration (CO₂ evolution) of asparagus in 0% oxygen (100% nitrogen) was almost 50% less than it was in air. Holding asparagus in 1% oxygen and 99% nitrogen reduced respiration about 30% as compared to air. Respiration of mushrooms at 60° F. was reduced to 1/6 the rate in air after 4 hours at 0% oxygen (100% nitrogen). After 24 hours in 0% oxygen, the atmosphere was changed to air and respiration increased rapidly so that within 2 hours it had reached that of mushrooms held continuously in air. (MQ 2-71)

2. Chilling Injury of Eggplant. Low, but nonfreezing temperatures seriously affected the quality of eggplant fruits. Chilling injury, not apparent at the low temperature, developed rapidly when fruits were removed to 70° F. Fruits developed visible injury at 70° following 6 days at 32° or 40°. The injury increased sharply as the holding period was increased. Eggplant fruits top iced and stored at 45° for 7 days also developed serious chilling injury. (MQ 2-86)

F. Postharvest disease control

1. Chinese Cabbage. A 14-hour delay between harvest and precooling may occur in the handling of Florida vegetables. Florida-grown inoculated Chinese cabbage held 6 to 12 hours at 85° F. before precooling, developed bacterial soft rot within 1 week at 35° F. The longer the delay the greater the amount of decay. (MQ 2-47)

2. Irradiation of Vegetables. Gamma irradiation had no effect on the incidence of decay on artichoke buds, on five varieties of lettuce, or on sweet corn. Irradiation at 200 to 300 krad resulted in internal and external discoloration of artichoke buds, in brown spotting and death of lettuce leaves, and in increased denting of the kernels in sweet corn. Stem scar mold of cucumbers and summer squash was significantly reduced by 300 krad, but the treatment caused undesirable softening and yellowing. Sweetpotatoes were severely injured by 25 krad or more. Sprouting was inhibited by 8.25 krad during a subsequent 6 months' storage period, with only a very slight increase in decay. Irradiation greatly increased the susceptibility of sweetpotatoes to chilling injury. This work will be completed upon preparation of a report. (MQ 2-82)

3. Onions. After 4 months' storage, New York-grown Downing Yellow Globe onions harvested from plants spaced 5 per foot in single rows in the field developed 4.7 percent Botrytis neck rot; those spaced 13 plants per foot developed only 2.6 percent. In another test, decay averaged 26 percent from plots with 8 plants per foot, and about 1/2 as much decay from plantings spaced 13 plants per foot. The closely spaced onions had necks

of smaller diameter which were less subject to decay. None of the top-killing treatments, Diquot, Herbisan, or Penta were effective in reducing storage decay. (MQ 2-95)

4. Peppers. In tests in Texas, hot water (128° F. for 1½ minutes) or Phytomycin (100 ppm) gave fairly good control of bacterial soft rot of long-stemmed peppers, confirming results obtained previously. Chlorine (500 ppm) was much less effective. Adding chlorine (250 or 500 ppm) to hot water treatment improved decay control over that obtained with hot water alone. The benefits from any of these treatments were nullified when the treated peppers were subsequently hydrocooled, either without or with chlorine (500 ppm) in the water. Peppers with jagged stem-breaks collected in the field and packing shed, developed three times more soft rot infections than those with smooth breaks (abscission).

Brushes and toweling in the waxer apparently were the major source of infection in the packing line. Decay in peppers collected after waxing amounted to 51% compared with 11% in those collected before waxing. This work will be terminated upon completion of a final report. (MQ 2-87)

Low temperature appears to be the principal predisposing factor in the susceptibility of bell peppers to Botrytis rot. Decay of unwounded pepper pods increased sharply at 40° F. as compared to 50° confirming previous results. High relative humidity also favors decay. (MQ 2-52)

5. Sweetpotatoes. Shipping tests from North Carolina demonstrated that a 450 to 900 ppm Botran (2,6 dichloro-4-nitroaniline) dip controlled soft rot of sweetpotatoes during marketing as well as, or better than, the current commercial treatment employing SOPP (sodium o-phenylphenate). Botran caused less chemical injury to the sweetpotatoes and was easier to use in the packinghouse. A combination of hot water and SOPP was more effective than hot water alone and required only 1/5 the concentration of SOPP now used commercially. (MQ 2-73)

It has been reported in the literature that Rhizopus stolonifer produces a pectic enzyme, pectinmethylesterase, which plays an important role in the pathogenesis of the fungus in sweetpotatoes. Evidence obtained at Beltsville indicates that the enzyme is a product of the host rather than the organism. No evidence has as yet been obtained indicating a possible role of the enzyme in either pathogenesis by the fungus or disease-resistance by the host. (MQ 2-60)

6. Tomatoes. A dry, firm decay of mature green tomatoes caused by a bacterium was studied at Chicago. Physiological, pathological and histological studies indicate that the organism is an Enterobacteriaceae and a strain of Aerobacter cloacae. (MQ 2-64)

Florida-grown mature-green tomatoes of Grothan Globe and Homestead varieties ripened more rapidly after harvest than those of the Indian River and

Manapal varieties. In addition, Grothan Globe and Homestead tomatoes were less subject to Alternaria decay following chilling than the slower ripening varieties, confirming previous results. Commonly used postharvest fungicides had little effect in the control of Alternaria decay of chilled tomatoes. (MQ 2-88)

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Objective Measurement of Quality

Gates, J. E., Cooler, J. C., Kramer, A. and Yeatman, J. N. 1964. Development of Objective Methods for Measuring the Character Factor of Quality in Canned Southern Peas. Proc. Amer. Soc. Hort. Sci. 84: 399-408. (BS 3-75)

Quality Maintenance in Handling and Packaging

Ceponis, M. J. and Griffin, G. J. 1963. Effect of Heat-tunnel Temperatures on the Quality of Shrink-film Wrapped Lettuce. USDA, Marketing Research Report 634. (MQ 2-64)

Harris, C. M. and Lipton, W. J. 1964. Carbon Dioxide Injury to Cauliflower Wrapped in Non-ventilated Films. Produce Marketing. 7(7):35 (Exploratory Research)

Hatton, T. T. and Reeder, W. F. 1963. Effect of Field and Packing House Handling on Bruising of Florida Tomatoes. Fla. State Hort. Soc. 76:301-304. (MQ 2-36)

Johnson, R. M. and Thompson, J. A. 1964. Burlap and Multiwall Paper Bags for Handling and Storing Pea Beans. USDA, AMS 528. (MQ 2-30)

Kushman, L. J. and Covington, H. M. 1963. New Treatment Extends Sweet-potato Shelf-life. Produce Mktg. Sept. pp. 21-22. (MQ 2-73)

Kushman, L. J., Hardenburg, R. E. and Worthington, J. T. 1964. Consumer Packaging and Decay Control of Sweetpotatoes. USDA, Marketing Research Report 650. (MQ 2-73)

Stewart, J. K. and Barger, W. R. 1963. Effects of Cooling Method, Pre-packaging and Top Icing on the Quality of Brussels Sprouts. Proc. Amer. Soc. Hort. Sci. 83:488-494. (BS 2-71)

Thompson, J. A., Johnson, R. M. and Kingsolver, C. H. 1964. Comparison of Bulk and Bag Shipments of Dried Beans. USDA, ARS 51-3. (MQ 2-30)

Quality Maintenance During Transportation

Harvey, J. M. and Stewart, J. K. 1964. Research on transit temperatures

in piggy-back trailers. Proc. Fruit and Vegetable Perishables Handling Conf. Davis, Calif. pp. 92-96. (MQ 2-84)

Harvey, J. M. 1963. Improved Techniques for Vacuum Cooling Vegetables. ASHRAE Jour. 5(11):41-44. (MQ 2-80)

Lipton, W. J. and Stewart, J. K. 1963. Effect of Precooling on the Market Quality of Globe Artichokes. USDA, Marketing Research Report 633 (MQ 2-2)

Stewart, J. K. and Couey, H. M. 1963. Hydrocooling Vegetables: A Practical Guide to Predicting Final Temperatures and Cooling Times. USDA, Marketing Research Report 637. (MQ 2-2, MQ 2-13, MQ 2-14, MQ 2-55)

Postharvest Physiology

Lipton, W. J. 1963. Post-harvest Changes in Amount of Tip Burn of Head Lettuce and the Effect of Tip Burn on Decay. Plant Disease Reprtr. 47:875-879. (MQ 2-58)

Lipton, W. J. 1963. Influence of Maximum Air Temperatures During Growth on the Occurrence of Russet Spotting in Head Lettuce. Proc. Amer. Soc. Hort. Sci. 83:590-595. (MQ 2-11)

Parsons, C. S. 1964. Storage in Nitrogen: Effect on Fruits, Vegetables, and Flowers. Ind. Oxygen Mfrs. Assn. "The Broadcaster". Feb. 4, 1964. (MQ 2-71)

Postharvest Disease Control

Beraha, L., and Smith, M. A. 1964. A Bacterial Necrosis of Tomatoes. Plant Disease Reprtr. 48:558-561. (MQ 2-64)

Covington, H. M. and Kushman, L. J. 1963. Stop That Rot. American Vegetable Grower 11(10):14, 26, 27. (MQ 2-73)

Friedman, B. A. 1963. Carbon Source and Tetra. olum Agar to Distinguish Virulence in Colonies of Erwinia Carotovora. Phytopathology 54(4): 494-495. (MQ 2-3)

Friedman, B. A., and Ceponis, M. J. 1964. Acid Production by Erwinia Carotovora in Vivo as a Factor in Virulence. Phytopathology 54(2): 237. (MQ 2-3)

Johnson, H. B. 1964. Effect of Hot Water Treatments and Hydrocooling on Postharvest Bacterial Soft Rot in Bell Peppers. USDA, AMS 517. (MQ 2-87)

Kaufman, J., Lorbeer, J. W. and Friedman, B. A. 1964. The Relationship of Fungicides and Field Spacings to Botrytis Neck Rot of New York-grown Onions. USDA, ARS 51-1. (MQ 2-95, pending)

- Kushman, L. J. 1963. Estimation and Maintenance of Sodium O-phenylphenate Concentration in Sweetpotato Treating Solutions. USDA, AMS 521. (MQ 2-73)
- Segall, R. H., Griffin, G. J. and Melvin, C. F. 1963. Increasing the Shelf Life of Escarole with N⁶ Benzyladenine. Proc. Fla. State Hort. Soc. 76:122-127. (MQ 2-47)
- Segall, R. H., Hayslip, N. C., and Walter, J. M. 1963. Effect of Post-harvest Temperatures on Several Tomato Varieties Harvested at the Mature-green Stage. Proc. Fla. State. Hort. Soc. 76:172-177. (MQ 2-88)
- Smith, M. A., Ramsey, G. B. and Green R. J. 1964. Market Diseases of Fruits and Vegetables. Purdue Univ. Agr. Ext. Serv. Ext. Cir. 523. (MQ 2-64)

TRANSPORTATION AND MARKETING FACILITIES
Transportation and Facilities Research Division, ARS

Problem. Returns to producers and prices paid by consumers for horticultural crops are adversely affected by the use of inefficient marketing facilities, equipment, and methods. Better work methods, techniques, devices, operating procedures, equipment, and facility designs are needed for precooling, conditioning, storing, handling, cleaning, washing, waxing, sorting, sizing and packing potatoes, citrus fruits, deciduous fruits, vegetables, and other horticultural crops. Such improvements are needed at both shipping points and terminal markets. They would increase the productivity of labor, prolong the storage life of the commodities, reduce bruises and injuries to these products, reduce marketing costs, expand consumption, and reflect greater returns to producers.

It costs about 8 billion dollars a year to package food products, but without shipping containers and various other types of packages it would be impossible to move farm products efficiently from the widely dispersed areas of production through our complex marketing system to millions of consumers. New or improved packages and containers must be developed and evaluated to do this job more effectively. Continuing changes characterize the American marketing system. In protecting, distributing, and selling perishable agricultural commodities, packages and containers must respond to a number of marketing system changes.

The job of the research program in this area is to see that packages and containers keep pace with changes in the marketing system and reduce the cost of handling, transporting and storing agricultural commodities. It also seeks to improve service to consumers, promote greater sales of farm products, and increase the income of producers.

The cost of transporting farm products to market in 1963 was 5 billion dollars. Cost of transporting supplies used in farm production totaled more than one billion dollars. Further, costs of other marketing and production functions, such as loading and unloading vehicles, packaging storage and processing, also are affected by the efficiency of transport. These costs are important to the American farmer because they influence the return he receives from the sale of his products. They also are important to the American consumer because they influence the price he pays for his food. Therefore, the prosperity and efficiency of our entire agricultural industry and the economic well-being of the American consumer are closely tied to the efficiency of our transport system.

USDA AND COOPERATIVE PROGRAM

This is a continuing long-range research program covering the development of improved work methods, techniques, devices, operating procedures, equipment, and facility designs for precooling, conditioning, storing, handling, cleaning, washing, waxing, sorting, sizing, and packing vegetables.

Vegetable research is conducted by the Hyattsville office at both terminal markets and at shipping points. The Gainesville, Fla., and Athens, Ga., field offices also conduct work at shipping points, in commercial packing plants and in laboratory facilities of the University of Florida. Work at shipping points is in cooperation with the Florida and Georgia Agricultural Experiment Stations, and with the Market Quality Research Division. Sweet-potato work in North Carolina is conducted under a cooperative agreement with the North Carolina Station. Work on terminal markets, covering the wholesale distribution, is conducted by the Hyattsville office in the warehouses of selected vegetable wholesalers. The Federal effort devoted to research in this area during the fiscal year 1964 total 12.3 professional man-years of which 1.3 was on vegetables.

Work on consumer packages and shipping containers is a continuing program of applied research conducted by marketing specialists, industrial engineers, and agricultural economists to (1) develop new or improved consumer packages, master containers, packing materials, and shipping containers for agricultural products; (2) evaluate them from the standpoint of cost of materials and direct labor to pack, and their ability to reduce product damage and increase product salability; (3) determine at which point in the marketing system packaging can be done most effectively; (4) improve the efficiency of packaging methods to cut costs; (5) investigate the needs for and benefits of container standardization and simplification. The program is carried on in cooperation with experiment stations and industry in California, Washington, New York, and Florida; at branch field stations in Orlando, Florida; Fresno, California; and Yakima, Washington; in other main producing areas; and in the principal terminal markets. The Federal professional man-years involved were 2.0.

The economic-engineering research in this field is a long-range program. It seeks to develop improved transport facilities, equipment and techniques and more efficient ways of using them in transporting agricultural products and supplies. It is interdisciplinary in nature, drawing upon the training and experience of economists, mechanical and industrial engineers, marketing specialists and various other scientists. All the work is done with the cooperation of transport firms, transport and refrigeration equipment manufacturers and lessors, trade associations, State universities and experiment stations. Field studies are carried out throughout the U. S. and on overseas shipments. Only one field station, Orlando, Florida, is permanently maintained to support this research program. Part of the work is accomplished through research contracts and cooperative agreements.

At the present time work is underway in each of the following fields: (1) transport equipment, (2) refrigeration equipment and techniques, (3) better utilization of transport equipment and techniques, (4) loading methods, including unitized loading, (5) development and evaluation of pallet containers, and (6) overseas transport.

The Federal professional man-years involved were 3.5 in F.Y. 1964.

PROGRAM OF STATE EXPERIMENT STATIONS

Research concerned with the economics of marketing at the State Agricultural Experiment Stations is reported under the appropriate areas of work of the Multiple Use Report, Marketing Economics Division. Likewise, research dealing with facilities and transportation conducted by the agricultural engineers at the State Experiment Stations is reported in the Multiple Use Report of the Agricultural Engineering Division, Areas 4, 5, and 9. Related research in food science and technology is reported in the Multiple Use Report of the Utilization Research and Development Divisions.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Handling and Packing Vegetables

At Gainesville, Fla., this research has as its objective the development of improved work methods, equipment, devices and operational procedures for the handling and preparation for market of vegetables at shipping points.

A manuscript on packing mature-green tomatoes at Florida shipping points, which was completed during the year, covers container assembly, filling containers, checkweighing and closing filled containers, handling stacks of filled containers with two-wheel clamp-type handtrucks, and loading for shipment. Changes in equipment and layout of the packing stations are described in the report to show how packinghouses handling the equivalent of 200,000 sixty-pound containers can save up to \$7,000 annually in equipment and labor costs. This report should be released and distributed during the last quarter of 1964.

Labor costs were estimated for the present complete operation of cutting, sizing, and packing celery into crates and of handling packed crates from the field to the precooling plant, and moving them through the hydrocooler and into a railroad car or semi-trailer truck for shipping. Flow process charts, system descriptions, and estimated labor requirements were prepared for improved handling systems which offered potential cost savings as compared to the present system. The reduction in crew size is sufficient with the best proposed system to realize an estimated labor savings of 7.8 cents per crate from present labor costs of 22.6 cents per crate (or 35 percent) for celery cutting, sizing, packing, precooling, and loading crates for shipment.

An alternate system of handling, which was developed for growers who wish to retain celery packing in the field, utilizes the mule-train field packing unit as presently used in celery harvesting. A trailer equipped with 5 loading platforms is towed behind the mule-train. Crates of each size of celery are stacked on separate loading platforms. Completed pallet loads are lowered to the ground by hydraulic actuated platforms. A field truck with a hydraulic hoist and a pallet pickup attachment picks up the pallet loads and transports them to a central precooling plant. At the plant, forktrucks unload palletized stacks of crates from the truck and deposit them in the hydrocooler. Forktrucks are also used to transport precooled stacks of

crates to a railroad car or semi-trailer truck for shipment. Estimated savings of labor and equipment costs for this system of handling are two cents per crate as compared to the present system of harvesting, sizing, packing, precooling, and loading for shipment.

A field truck with hoist, which would be used in the latter system of handling, was tested to determine its feasibility in a muck celery field. The equipment performed satisfactorily with the exception of a minor center of gravity design problem which was corrected later. Some care is also necessary on the part of the operator to prevent the vehicle turning over on the soft muck field when the load weighing 2,000 lbs. is picked up at right angles to the bed of the truck.

Handling tests were also conducted to determine feasibility of handling celery in bulk from field to central packing facility. In the tests, celery stalks were cut in the field, dropped into 47- by 47- by 30-inch pallet boxes, transported 2 miles, and evaluated for scuffing, bruising, and petiole breakage injuries. The tests were designed to compare effects of jumbled and oriented stalk arrangement in the bulk container and degree of petiole stripping completed in the field prior to placing stalks into the bulk container. Results of the experiment indicate that significantly less injury was received by non-stripped stalks handled in jumbled arrangement in pallet boxes than was received by stalks that were handled after being completely stripped in the field. There was no significant difference in injury between stalks handled in oriented and jumbled arrangement in the bulk container except when handling completely stripped stalks. Non-stripped stalks which were handled in jumbled arrangement in pallet boxes had major scoreable injury on 0.24 percent of the stalks, minor scoreable injury on 0.48 percent of the stalks and minor bruising injury on 3.34 percent of the stalks.

B. Cooling

This research at Gainesville, Fla., is designed to develop improved methods, operating practices, and techniques for use in existing and new facilities for more efficient cooling of vegetables. The research is directly related to that on the cooling of celery in unit loads previously reported.

Work on this project was confined to the preparation of the manuscript, "Forced-Air Precooling Spring Crop Potatoes," which was based on data obtained earlier on four precooling test runs on potatoes in 100-pound bags using forced-air as the precooling medium. It was found that potatoes can be precooled with forced air colder than 32° F., without damage, as long as the surface temperature does not go below 28.9° F. Present portable air cooling units require 4 to 6 hours to cool potatoes in a railroad car or trailer truck. Forced-air precooling with air below 32° could reduce the temperature of potatoes from 90° to 60° F. in less than 1 hour and offers the possibility of using this system of precooling in the future.

C. Handling Vegetables in Pallet Boxes

1. Tomatoes. Recent developments in the production and harvesting of tomatoes, such as mechanical harvesting for processing, has brought about an urgent need for the development of larger containers than field boxes for handling this commodity. Because of this need, research on handling and ripening tomatoes in pallet boxes has been undertaken at East Lansing, Mich., under a cooperative agreement with the Michigan Agricultural Experiment Station.

The pallet boxes designed and constructed during the previous report period were used initially for handling mechanically harvested tomatoes in order to evaluate the various types of pallet boxes and the injury they cause to tomatoes. Hand harvested tomatoes were used as a check lot.

Arrangements made to ship mature-green and pink tomatoes from Homestead, Fla. to East Lansing, Mich. for the purpose of evaluating the use of several pallet boxes for the handling and shipment of tomatoes over long distances, were abandoned due to a very severe frost in the Homestead area. Arrangements were then made with a shipper near Montecello, Ark. to complete these tests. Tomatoes were packed into baskets and either dumped or placed by hand into pallet boxes. Nine 25-pound crates, which are commonly used in Arkansas, were filled and accompanied the shipment of pallet boxes. The containers were loaded onto a 2½-ton truck and hauled directly from Arkansas to East Lansing, Mich., a distance of 975 miles.

The comparison in bruising of tomatoes shipped in 25-pound crates and in 670-pound pallet boxes indicates that pallet boxes offer an excellent shipping medium for green tomatoes. By wrapping and packing the tomatoes in pallet boxes, the bruising will not be higher than when 25-pound crates are used. Dumping the tomatoes in a pallet box results in an increased percentage of bruising as compared to dumping the tomatoes in 25-pound crates. The wood pallet box performed better than did the plastic or mesh-wire pallet boxes. The cooperator's final report on this project contains the detailed results of this research and will serve as a manuscript for a Department publication.

2. Sweetpotatoes. This research is designed to increase the efficiency and reduce the unit cost of handling, curing, storing, and preparation for market of sweetpotatoes and to minimize losses from spoilage and deterioration. This work is being conducted at Raleigh, N. C., under a cooperative agreement with the North Carolina Agricultural Experiment Station and the North Carolina State Department of Agriculture.

Handling and curing tests were continued with palletized loads of two types of wirebound field crates at two storage houses. Bushel baskets handled in the usual way were used as check lots or control.

Weight loss during the two month period of curing and storage for the crate was about 35 percent less than in the bushel baskets. Defects which were

severe enough to drop the grade level amounted to 4.1 percent of original weight for crates and 9.1 for baskets. Non-grade defects which effect appearance but not grade were about 25 percent less for the crates. In total, out of a 100 pound lot of sweetpotatoes about 89 pounds were marketable when handled in crates and about 80 pounds when handled in bushel baskets.

The preliminary report on, "Pallet Boxes and Palletized Containers for Handling and Storing Sweetpotatoes" was revised to include results of the second year's work.

D. Handling and Packing Fruits and Vegetables on Terminal Markets

1. Tiering Devices and Equipment. This research by the Hyattsville office was directed toward reducing the cost of storing fruits and vegetables at the wholesale level by increasing the utilization of available storage space in wholesale fruit and vegetable warehouses. During the report year work in this area was confined to the editing and publication of Marketing Research Report No. 622, "Storing Fruits and Vegetables on Pallets in Wholesale Warehouses."

2. Loading Out Delivery Trucks. The purpose of this research was to evaluate and compare the relative efficiency of selected methods and types of materials handling equipment for order assembly and truckloading used by wholesale distributors of fresh fruits and vegetables supplying both affiliated and non-affiliated retail stores so as to reduce unit costs and minimize spoilage and waste. The research was cooperative with the Wholesaling and Retailing Research Branch. During the report period work in this area was confined to the editing and publication of Marketing Research Report No. 665, "Three Methods for Loading Out Produce in Warehouses."

E. Consumer Packages and Shipping Containers.

1. Lettuce. Prepackaged lettuce--Test shipments and commercial shipments of lettuce prepackaged at shipping point have arrived in a condition as good as or better than conventionally packed unwrapped lettuce.

When lettuce is prepackaged at shipping point, about one-third of the weight of the lettuce shipped is eliminated by removal of the wrapper leaves. For this reason it costs about 30 cents less per box of 24 heads to ship wrapped lettuce from Salinas, California., to New York City.

Material and labor costs to prepackage lettuce at shipping point were 30 to 43 cents higher per box than to pack unwrapped lettuce. Higher development, overhead and capital expenses pushed the additional unit cost to about 50 cents--the premium usually charged for prepackaged lettuce. The cost of prepackaging lettuce at shipping point does not add to the

total cost of marketing lettuce because the costs of performing these operations is merely shifted from the retailer to the shipper. Therefore, the chief net advantage in prepackaging lettuce at shipping point is the saving in transportation costs which could amount to several million dollars annually.

Some consumers, accustomed to soft films, did not like the hard feel of polystyrene in which most of the prepackaged lettuce was wrapped. To overcome this resistance, the use of softer films was explored. Polypropylene, polyethylene and polyvinyl chloride films were evaluated. These softer but less permeable films have not worked well under adverse quality and handling conditions that occur frequently in the lettuce industry.

Lettuce shipped by air freight--The economic feasibility of shipping lettuce by air freight was explored. The extra cost of shipping lettuce by air over rail is as follows:

Freight Rates - Salinas, California to New York, New York

<u>Type of Pack</u>	<u>Rail</u>	<u>Air</u>	<u>Difference</u>
Unwrapped lettuce in corrugated boxes (47 lbs.)	\$1.31	\$3.43	+\$2.12
Prepackaged lettuce in corrugated boxes (32 lbs.)	.99	2.49	+ 1.50
Prepackaged lettuce in experimental paper bag-type shipping container (30.lbs.)	--	2.24	+ 1.25

By using an experimental paper bag as a shipping container, about 10 cents is also saved by lower container cost. The additional costs of shipping packaged lettuce in corrugated boxes by air as compared to shipping unwrapped lettuce by rail was \$1.18 per box--about 5 cents per head additional shipping cost.

2. Asparagus. A cheaper container for air freight shipments of asparagus was developed. Asparagus packaged in 1-1/2 pound waxed chipboard cartons was packed in a large combination fiberboard and wood shipping container. The capacity of the shipping container was 150 pounds and 96 packages were packed in it. Only one wax coated fiberboard layer divider supported by three vertical fiberboard panels was used. The staples fastening the fiberboard to the wood pallet failed, indicating the need for improved fasteners and stronger fiberboard. If a container of this type could be developed, it would save about 50 cents in container costs and about \$1.00 in freight charges for the reduced weight. This would be equivalent to about 25 cents per crate.

3. Celery. Prepackaged at shipping point--A stretchable film sleeve wrap and a perforated polyethylene film bag for celery stalks were evaluated. The sleeve wrap left both ends of the celery stalks exposed. The polyethylene bag was left open so the stalks could be easily removed. Celery packaged in the perforated polyethylene bag showed significantly less moisture loss and had a better appearance than the non-packaged or sleeve wrapped celery. Also, a rail test shipment and a simulated laboratory test showed less bruising for celery stalks packaged in the polyethylene bags than for the non-packaged or sleeve wrapped stalks.

Crate for 14-inch stalks--A celery crate two inches narrower than the one most commonly used was evaluated to determine its practicability and acceptance. The new crate was designed to hold the same number of stalks as the conventional crate, but the stalks were trimmed to 14-inch lengths instead of the conventional 16 inches. Test shipments to eastern terminal markets showed that the total amount of bruising in conventional crates averaged 12 percent as compared to 10 percent bruising found in the new 14-inch crates. The leafy ends of the 14-inch stalks were more discolored and less attractive than the conventionally-packed 16-inch stalks. Although no container damage was observed for either container, the 14-inch crates appeared to be more compact and sturdy than the conventional crates. The trade reaction to the new crates was mixed. Some receivers failed to notice the difference between the 14-inch cut and the 16-inch cut. Some also commented that the 14-inch length did not leave enough stalk for retrimming. Potential advantages of using 14-inch crates include (1) lower transportation costs resulting from heavier loads, (2) savings in container costs, and (3) easier handling from reduction in gross weight.

4. Beans. The development and evaluation of consumer packages, master containers, and methods of prepackaging fresh pole beans was initiated during the 1964 marketing season. Various types of molded pulpboard, plastic, and chipboard trays overwrapped with shrinkable films and flexible bag packages were packed at shipping point to determine the best combination of materials and methods of packing them. The tray packages held from 1-1/4 to 1-1/2 pounds of fresh beans, and two sizes of polyethylene bags held 1-1/4 and 2 pounds of beans.

The experimental packages delivered the fresh pole beans in excellent condition. Reactions of the trade toward the packaged beans were mixed with some preferring the tray-type consumer units and others favoring the polyethylene bag packages.

Combined material and packing labor costs ranged from 5.9 to 7.5 cents per pound of fresh beans packaged in the rigid trays overwrapped with transparent film; and from 3.9 to 4.8 cents per pound of beans packaged in polyethylene bags.

Fiberboard master containers were designed for shipping the experimental packages. The containers held 24 1-1/4 pound trays, 18 2-pound polyethylene bags, and 30 1-1/4 pound polyethylene bags.

F. Transport Equipment

1. Thermal Rating of Refrigerated Trucks. This research is being conducted in cooperation with the National Bureau of Standards at the NBS facility in Washington, D. C. Its purpose is to develop a standard rating method to measure the thermal efficiency of refrigerated delivery truck bodies under conditions of 100° F. ambient, 50 percent ambient humidity, and 0° F. interior temperature.

Work was continued on the measurement of the rates of air exchange and the effect on load cooling caused by opening the door of a refrigerated truck. Preliminary tests were made using thermocouples, heat flow meters, and rapid response air flow probes designed and constructed at NBS. These instruments are used in conjunction with metered liquid nitrogen to maintain the steady-state interior temperature prior to the door opening and to restore the temperature immediately after the door is closed. Nitrogen from a self-pressurizing Dewar container is admitted to the interior through solenoid valves controlled by an air temperature multiple thermocouple grid. The heat load caused by the door opening can be determined by measuring the nitrogen required in excess of that required to maintain the steady-state temperature difference.

It is now anticipated that a final report will be issued during the next year.

2. Air Circulation in Refrigerated Trailers. The purpose of this research is to determine the most practical system for circulating cold air to obtain uniform temperature throughout a trailer load of frozen food. Previous tests have shown that temperatures at the front of a trailer near the cooling coils can be at 0° F. while other locations in the load may be several degrees above zero. This study seeks to find the best combination of blowers, air ducts, floor racks, and wall spacers to eliminate areas of high temperature. This is a cooperative program with the National Bureau of Standards being conducted at the NBS facility in Washington, D. C.

Work during the reporting period was devoted to analysis and reduction of the large amount of data obtained from previous trailer tests. Preliminary analysis of the tests comparing continuous and cyclic blower operation indicated somewhat greater load temperature changes during refrigeration "off" periods under the 12° F. thermostat differential, compared to 4° F. and 6° F. when the blower was operated continuously. The thermostat sensing element was located in the return air stream near the evaporator coils and behind a bulkhead near the front of the trailer. The space forward of the bulkhead warmed faster than the cargo space when the blower was cycled off. With the blower under constant operation under the

refrigeration "off" cycle, the forward space warmed more slowly, at approximately the same rate as the cargo space.

The 12° F. thermostat differential produced exposed cargo surface temperature changes of about 10° F. when the blower was cycled and about 8° F. when the blower operated continuously. Center cargo temperatures changed about 0.5° F. in each case. All tests were conducted with ambient temperatures of 100° F. and mean interior (return air) temperature of 0° F.

3. Liquid Nitrogen Refrigeration for Frozen Food Trailers. The objective of this study is to determine whether it is practical to use liquid nitrogen as a refrigerant in vehicles transporting frozen foods. Previous research has shown that liquid nitrogen and liquid carbon dioxide will provide 0° F. temperature for frozen foods. However, analysis shows that these expendable refrigerants are more costly than conventional mechanical systems. This project is being discontinued until costs of expendable refrigerants are reduced sufficiently to make their use economically feasible.

4. Multi-Purpose Transport Vehicles. Van Containers--A design concept for a multi-purpose van container was developed during the year. It was described in a press release which generated widespread interest among steamship lines, railroads, freight forwarders, trucking groups, transport, and refrigeration equipment manufacturers. Meetings were held with representatives of these groups and several offered to make available their facilities and technical assistance in engineering, construction and testing of the prototype van. An application for public-use patent on the van is now being processed.

The container can be used to haul both frozen and nonfrozen perishable products and nonrefrigerated cargo. It also can be used to carry freight by rail piggyback, highway, water (fishyback), and perhaps by air in moving farm products to the consumers.

Trailers--Research was begun late in the year to develop practical, low cost, conversion systems by which conventional refrigerated trailers and dry cargo vans can be made dual-purpose vehicles for use in transporting bulk as well as packaged cargo. It is being carried out under a cooperative agreement with the Oregon Agricultural Experiment Station. Several trailers equipped with prototype conversion systems are now being tested in cooperation with several trucking firms in the Pacific Northwest. Initial results indicate that the rates of vehicle utilization are materially increased when the conversion systems are used. However, the project has not progressed far enough to obtain adequate data on vehicle utilization rates, operating costs, and revenue yields.

5. Improved Ventilated Piggyback Trailers. Research to develop improvements in rail piggyback trailers which will facilitate better product ventilation was continued during the year. Previous work showed that conventional highway trailers used for this service did not provide a flow of outside air through loads of perishables sufficient for adequate cooling.

Several trailers incorporating new ventilation systems were tested with shipments of watermelons from Florida to northern markets. One type van tested was equipped with adjustable scoops on the front ventilation doors to direct air into the van when hauled rear-end-forward on rail piggyback flat cars. Another type studied had under-floor scoops to direct air into the cargo area where the ram-effect forced it upward through the load and out the exhaust ports in the upper sidewalls of the van. The latter type trailer gave the best results. In paired tests the temperature of watermelons in a conventional van rose three degrees during transport while those shipped in the van with under-the-floor air scoops cooled 15 degrees. Additional work to develop further refinements in this system and to develop and test new equipment is being continued.

G. Transport Techniques

1. Heavier Loading of Watermelons. All field work has been completed, the data analyzed and results evaluated on all-rail and rail-piggyback shipments of long-type watermelons loaded 6 and 7 layers high compared with the conventional 4 and 5 layer loads. Additional data on freight costs were developed during the year and integrated with previously developed information on product damage, cooling rates and loading costs. The initial report has been revised and is being reviewed for publication. This project will be terminated after publication of the report.

This work demonstrated that shippers can take advantage of multiple-minimum or per-car rates to reduce transport costs through heavier loading provided proper precautions are taken to load only sound, disease-free melons of uniform size and shape. It was found that rail-piggyback shipments may be loaded 8 and 9 layers deep with substantially less melon damage than standard rail car shipments loaded only 6 and 7 layers deep. The use of piggyback trailers for delivery of melons to retail outlets has increased the flexibility of marketing, reduced handling costs, product damage and eliminated temporary storage of melons in wholesale warehouses and transport vehicles.

2. Loading Methods for Fresh Peas. The results of this study show that continuous stave baskets and the alternately inverted loading method can be used to reduce the amount of physical damage during rail transport. However, less refrigeration is obtained from top ice on the load when the crosswise offset pattern is used. Damage was also reduced and product refrigeration was not impaired when the amount of top ice was reduced by about half and half-stage bunker icing was used.

The report on this research is now being revised for publication during the coming year. This project will be discontinued.

3. Loading Patterns for Bagged Onions. More than 100 rail shipments of bagged onions from producing areas in Texas to eastern and midwestern markets were studied to obtain additional information on a new air-flow loading pattern developed in previous research. The new load pattern provides more and larger channels which permit the air to move freely through the load. More of the air coming into the refrigerator car circulates through the load to help remove excess heat and moisture. This helps to prevent development of decay. One shipper adopted the new loading method for all his shipments which totaled more than 100 carloads. It is anticipated that other shippers will adopt the new method next season.

All field work has been completed. The data will be analyzed and results evaluated, and a detailed report prepared for publication during the coming year. This project will be discontinued.

4. Unitized and Palletized Transport. A literature review of systems analysis and operations research applications to the handling and transporting of agricultural commodities was completed during the year. This information has been used to plan work in which this research technique will be used to evaluate different methods of unitized and palletized transport.

Observations were made of the operations of handlers and shippers of carrots in California, Arizona, and Texas to determine the feasibility of applying systems analysis and operations research techniques to improve transport and handling of this product. Data developed in this survey have been used to construct a "word model." This model may serve as the basis for constructing a mathematical model which can be used to predict the results of changes in any part of the transport system for a particular product.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Handling and Packing Fruits and Vegetables on Terminal Markets

Ferris, Richard T. 1964. Storing Fruits and Vegetables on Pallets in Wholesale Warehouses. Marketing Research Report No. 622, February 1964, 38 pp.

Lundquist, Arnold L. and Bouma, John C. 1964. Three Methods for Loading Out Produce in Warehouses. Marketing Research Report No. 665, June 1964, 44 pp.

Lundquist, Arnold L. 1964. Is Your Loading Out Method Efficient? Agricultural Marketing, Vol. 9, No. 7, July 1964, pp. 4 and 5.

1964. More Efficient Produce Warehouses. Agricultural Marketing, Vol. 9, No. 6, June 1964, pp. 6 and 7.

1964. Repacking Tomatoes. Agricultural Marketing, Vol. 9, No. 5, May 1964, pp. 14 and 15.

Consumer Packages and Shipping Containers

Mallison, Earl D. 1964. Shipping Containers for Tomatoes. Paper presented at the annual meeting of the Ohio Vegetable & Potato Growers Association, Columbus, Ohio, February 5, 1964.

Chapogas, Peter G. and Stokes, Donald R. 1964. Prepackaging Lettuce at Shipping Point. Marketing Research Report 670, pp 48, July 1964.

Stokes, Donald R. 1963. Improved Shipping Containers for Agricultural Products. Paper presented at the Fibre Box Association's Industry Growth Seminar, New York, New York, October 9-10, 1963.

Stokes, Donald R. 1963. How Good Packaging Benefits the Consumer. Paper presented at the annual meeting of the National Association of Marketing Officials, Brown Palace Hotel, Denver, Colorado, October 15, 1963.

Transport Equipment

Guilfoy, R. F., 1963. Liquid Carbon Dioxide Refrigeration in a Frozen Food Trailer. November 1963. AMS-522. pp. 15.

Clayton, J. E., 1964. USDA Transport Research--Past and Future. Paper presented at the National Conference on Handling Perishable Agricultural Commodities, Purdue University. March 1964.

Guilfoy, R. F. 1964. USDA Research in Transportation of Fresh Meats. Paper presented at the National Conference on Handling Perishable Agricultural Commodities, Purdue University. March 1964.

Guilfoy, R. F., 1964. Transport of Perishable Foods. Paper presented at the Annual Food Engineering Conference, Michigan State University. April 1964.

Transport Techniques

Press release, 1964. New Van Container Concept Developed by USDA. June 1964.

Hinds, R. H. and Robertson, J. K., 1964. Air-flow Loading Patterns for Truck Shipments of Early Potatoes. September 1964, MRR ____.

COOPERATIVE MARKETING
Marketing Division, FCS

Problem: Farmers are expanding their use of cooperative marketing. There are constant changes in transportation, processing, and distribution technology, and in market organization and practices, and changes on the farm itself. In view of these developments, farmer cooperatives and other marketing firms require research results to perform both efficiently and effectively. Such research can assist farmers to maintain and strengthen their bargaining power, increase efficiency, and meet the quality, quantity, and service needs of today's food and fiber marketplace.

Cooperative marketing is a major way for farmers to get maximum returns from their products in the current and rapidly changing market. Farmers own and control cooperatives specifically to increase their income from crops and livestock. Gains are not automatic, however. Cooperatives must plan, develop, and actually manage the specific marketing program and services that will yield the most for their members. Marketing cooperatives must know what the market demands. They must be able to compute the probable cost of different ways of serving the market. They must understand the possibility of major economies in a well coordinated joint sales program, and understand the methods and potentials of bargaining. Management must achieve minimum costs through improved organization, good use of existing plant and personnel, and the selection and use of new equipment and methods.

USDA AND COOPERATIVE PROGRAM

The Department conducts a continuing long-range program of basic and applied research and technical assistance on problems of marketing farm products cooperatively. Studies are made on the organization, operation, and role of farmer cooperatives in marketing. While most of the research is done directly with cooperatives, the results are generally of benefit to other marketing firms. The work is centered in Washington, D.C. Many of the studies, however, are done in cooperation with various State experiment stations, extension services, and departments of agriculture.

Federal professional man-years devoted to research in this area totaled 23.3, of which 1.3 was devoted to work on vegetables.

Research also is conducted under contract with land-grant colleges, universities, cooperatives, and private research organizations. During the period of this report, contract research was performed by universities and colleges in Florida, Iowa, Louisiana, Montana, North Dakota, and West Virginia, and by one private research company.

PROGRAM OF STATE EXPERIMENT STATIONS

The State stations maintain a very broad research program in commodity marketing, the findings of which are valuable to cooperatives and to other marketing firms. There are at this time nine projects in eight States that deal specifically with cooperative marketing. Five projects are commodity oriented and deal with grain, tobacco, milk, livestock, and fruits and vegetables. These projects seek to find out how cooperatives are adjusting or might better adjust to changes in market structure and marketing practices. In some instances researchers are studying the success and failure of cooperatives and the organizational structure. One study of the history of major cooperative marketing associations in the State will be published as a book and will undoubtedly receive nationwide attention.

Because of the growing interest in the role of cooperatives in market structure, one State recently initiated a major project in this area. The project leader views cooperative enterprises as a structural dimension of farm markets. The objectives and operating procedures of cooperatives will be studied to see if they have a unique impact upon market conduct and performance. If so, this may have significant implications for Government policies and programs.

The total research effort on cooperative marketing in the eight States is 3.4 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Coordination of Marketing

Operations and structure of a joint sales agency of vegetable processors in the North Central States were studied. Recommendations were made for strengthening this organization.

B. Improving Cooperative Sales and Distribution Methods.

In many commodity fields, wholesale and retail marketing practices have changed so much that sales and distribution methods need to be restudied from the farm level forward. Research on these problems included work in several commodities.

Celery. A survey was completed of celery buying preferences and practices of retail chainstore organizations and produce wholesalers. Research was conducted under contract with a private market research firm.

Dry Edible Beans and Peas. Analysis continued of ways for selected cooperatives marketing dry edible beans and peas to improve their marketing and distribution effectiveness. This work was conducted under contract by a private research organization.

C. Potentials in Cooperative Marketing.

Study continued on the present status and trends in cooperative marketing of these products. Research will include evaluation of the potential of cooperatives for increasing their operating efficiency and market effectiveness through integration, coordination, consolidation, expansion, or other means.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Markeson, C. B. "Sweets" Progress in Virginia. News for Farmer Cooperatives (April).

ECONOMICS OF MARKETING

Marketing Economics Division, ERS

Problem. Most agricultural processing industries are experiencing rapid and drastic changes in their market organization and practices. These changes are affecting both farmers and consumers. Research is needed to keep abreast of such changes and to indicate their probable consequences. There have been substantial advances in recent years in increasing efficiency and reducing costs through adoption of new technology in producing, assembling, processing, and distributing farm products. However, for producers and marketing firms to remain competitive additional information is needed on margins, costs, economics of scale and efficiencies possible in the marketing of farm products.

Marketing research also is increasingly concerned with evaluating present and prospective programs pertaining to agriculture, such as the Food Stamp Program and Federal Grading Activities and to the changing structure of market industries as this may influence the bargaining power of farmers. Research also is being directed to the economics of transportation and storage activities of both private firms and government. Increasing attention is being given to the longer-term outlook for various products and markets as an aid in better assessing the prospects for increasing industrial employment under the Rural Development Program and in assessing prospective interregional shifts in the areas of production and marketing for specific products.

USDA AND COOPERATIVE PROGRAM

The Department conducts a continuing program involving a series of studies to show: (1) Detailed analyses of marketing costs and margins in the various stages and channels in handling, processing, transporting, and distributing horticultural and special crops and related products; (2) comparative efficiency and costs of present agencies, organizations, methods, and practices in performing the services involved at each important stage in taking the crop products from farms to final users; and (3) the influences on costs and efficiency of such factors as grades and standards, methods of determining and maintaining product quality, and governmental regulatory and informational programs. On the basis of results of such studies, recommendations are made on possible means of increasing the efficiency of marketing, or increasing returns to growers, and of providing consumers with the choices they desire.

The Federal scientific effort devoted to this research in F.Y. 1964 amounted to 10.0 professional man-years.

PROGRAM OF STATE EXPERIMENT STATIONS

Vegetables. The largest segment of vegetable marketing research at the State agricultural experiment stations falls in the area of structure, practices and competition. This involves finding out where farmers sell their products, in what volume, and at what prices. One station has a project dealing with institutional buyers. This type of information is used as a basis for suggesting improvements in practices and policies. Another important segment is the determining of costs and efficiency in the assembly, processing, packaging, and selling. These studies involve economic-engineering type of studies in the analysis of alternative methods of performing the elemental functions which form the basis of marketing systems. Another important segment is the study of transportation costs and systems and its function in the competitive position of various producing areas. Merchandising and promotion studies deal with packaging, advertising and store displays, and consumer response.

A total of 14.4 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Structure, Practices and Competition

1. The competitive position of the Western vegetable processing industry is affected considerably by competition from areas nearer major markets and consuming centers. A comprehensive analysis of costs of producing, processing and the interregional competition in marketing asparagus is underway. A detailed analysis of labor utilization in asparagus canning operations shows possible savings of from \$16 to \$40 per hour of plant operation. Studies of tomato canning operations were initiated in August 1964.

2. Direct purchasing of fresh fruits and vegetables by retail chains has affected the structure of the wholesale market for fresh produce. A final report summarizing changes in the structure of 52 wholesale produce markets shows that direct purchases from shipping points by chains and affiliated groups increased from 12 percent of total market receipts in 1936 to 26 percent in 1958. During this time the number of produce wholesalers decreased by 15 percent.

A study of further changes in the structure, organization and practices since 1958 in the Philadelphia wholesale produce market is to be made this year giving particular attention to changes in adjusting to the new food center.

3. Marketing "pink" tomatoes is having a significant effect on marketing practices for tomatoes. A survey of 46 handlers of tomatoes in 27 receiving markets found that about one-half regarded the present system of grading vine-ripened tomatoes as inadequate. A study of the demand and substitution relationships for hothouse, vine-ripened and mature green tomatoes found the demand for all three types to be elastic, with hothouse tomatoes being the most elastic and mature green tomatoes the least elastic.

4. The Lower Rio Grande Valley fruit and vegetable market is being studied. Particular attention has been given to prices received by growers for tomatoes and citrus. The Valley tomato market appears to operate in a highly competitive manner. As a result of this project there is a better understanding of the relations between grower and f.o.b. prices and of marketing margins at shipping point and costs of assembling, handling, and packing. Growers seem willing to do more culling of tomatoes in the field. Similar analyses of prices are underway for citrus, carrots, and onions.

5. Changes in the structure of California fruit and vegetable markets are affected by transportation methods. A study of agricultural exemption, competition, and efficiency in the motor carrier industry disclosed that fruits and vegetables are the most important out-flow of exempt commodities originating in California. They accounted for 33 percent of the 1961 tonnage of agricultural commodities transported across the California border and for 45 percent of the total ton miles. Trucks hauled about 30 percent of outbound fruit and vegetable shipments. Further research is being done on the probable effects of two alternative transportation policies--the elimination of agricultural exemption, or the extension of agricultural exemption to other modes of transportation.

6. The market feasibility of radiation pasteurization of fruits and vegetables is being evaluated for the Atomic Energy Commission as a part of the "Atoms for Peace" effort. A survey of shippers and wholesalers suggested that successful market introduction of radiation-pasteurized fruits and vegetables would depend on an effective public education program. Also, they estimated that they could afford to pay one-fourth of a cent per pound for radiation pasteurization except for strawberries where they could pay 1.75 cents per pound. An economic evaluation of radiation pasteurization for strawberries indicates that reductions in losses at current price levels should exceed estimated costs for radiation pasteurization. Sufficient technological data were not available for an evaluation for grapes and peaches.

7. A study of market orders for fruits, vegetables and potatoes has indicated that quality regulations under potato marketing order programs have enabled producers to increase their returns. An analysis of prices received by market order and non-market order areas before and after the adoption of the programs indicate that prices received by producers in market order

areas have generally increased relative to prices received by growers in the non-market order areas. This price increase occurred in spite of large production increases in market order areas and a general production decline in non-market order areas. During F.Y. 1965 further analyses will be made of potato marketing orders and the affects of a rapidly growing processing industry on the effectiveness of potato market orders. An additional study of the tomato market order in Florida is underway. Industry discussion of the merits of reinstating the order called attention to the need for evaluation and analysis of tomato growers and handlers interpretations of the benefits of specific provisions of the order which was suspended, with particular emphasis on its effect on grower returns.

B. Information, Outlook and Rural Development

1. Additional economic information is needed concerning the feasibility of fruit and vegetable canning and freezing in the South. Growers, public officials, processors and potential investors need this information to assist in evaluating alternative resource uses in efforts to stimulate economic development. A study of the extent to which existing capacity in processing plants is being utilized is underway. The relative importance of vegetable production is being studied. Particular attention is given to showing changes in production by commodity and county. The feasibility studies of locating vegetable processing plants in northeastern North Carolina and the bootheel area of Missouri are underway with funds from the Area Redevelopment Administration, U. S. Department of Commerce.

C. Margins, Costs and Efficiency

Data for calculating marketing margins are maintained on a continuing basis for selected fresh vegetables sold in from 2 to 7 markets each. For these commodities in the period 1956-1962, marketing required an average of 63 percent of their retail value. The retail spread averaged 41 percent and the shipping-point to retailer spread averaged 22 percent. The remaining 37 percent of the retail price of vegetables was received by the growers and packers. The retail spread had an upward trend--increasing 11 percent from 1956 to 1962--while the shipping-point to retailer spread decreased 15 percent. The grower-packer share fluctuated but had a small net decrease.

D. Market Potentials

1. Market Testing Sweetpotato Flakes. An institutional market test on sweetpotato flakes, a new convenient-to-use product developed by SU, has been completed. Research results indicated a highly favorable reaction to this new product by management, kitchen help and customers of restaurants, and other types of institutional outlets. However, to build a large market for a new product, sales to household consumers must be promoted in the retail market. Introduction into the household market was delayed because of technical problems in packaging sweetpotato flakes. Therefore, it was considered desirable to conduct a small scale market test of sweetpotato

flakes in three types of packages -- tin cans, glass jars, and flexible pouches in paper boxes. The objective was to determine the type of package which offers the best potential based on customer purchases. In all phases of this research, consumers rated glass jars higher than the paper box and the tin can. This may partly be caused by the attractive visual appearance of the product in the jar. The results clearly indicate that no package disadvantage would attend the retail sale of sweetpotato flakes packed in glass.

2. Market Acceptance of Explosion Puff Dehydrated Products. Exploratory research has been initiated on the application of the explosive puff dehydration process on blueberries, a development of EU, for pie baking. These berries rehydrate much more quickly than conventionally dried materials. Preliminary testing of the dehydrated blueberries in pie baking operations showed the flavor of the product was satisfactory. Problems revealed in use of the berries in testing such as level and type of starch used can easily be overcome.

Further research is planned to obtain additional information on institutional market outlets which appear promising in terms of volume and types of products now used and the influence of the explosion puff dehydrated product on the overall costs and efficiency of institutional operations. It is anticipated that the experience gained in the work on blueberries will be applied to other explosive puffed products, such as apple slices and potato pieces.

E. Transportation

Transportation of Fresh Fruits and Vegetables. This is a two-phase project dealing with interstate rail and highway transportation of California and Arizona fruits and vegetables and is concerned with the flow patterns and trends associated with rail and highway movement of fresh produce from California and Arizona to other States.

Striking changes have taken place in the use of highway and rail carrier service. Since 1951, the share of interstate traffic dispatched from California and Arizona shipping points by rail has dropped from 87 to 70 percent of total movement from those areas. The decrease has occurred primarily because shipments moving to points west of the Mississippi River --short and intermediate range hauls--have been tending to go more and more by truck. Trucks have increased their share of shorthaul traffic from 67 to 83 percent of the total and their proportion of intermediate range hauls from 20 to 66 percent. These shifts in shippers utilization of carriers reflect the motor carrier's ability to offer attractive rates and fast service. In many instances motortruck transportation has become so much more attractive than rail service that some users are willing to pay higher charges for truck service than they would have needed to pay for the nearest comparable rail service.

The second phase of this study, based on receiver interviews, is scheduled for completion by December 1964. Preliminary findings confirm those of the shipper survey. Receivers utilize rail and truck service to improve plant operations and to serve customers better.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

- Kerr, H. W., and Hester, O. C. , August 1964. Recent Research on the Marketing of Sweetpotato Flakes. ERS-194. 5 pp.
- Bennett, Robert M. August 1964. Interstate Hauling of California-Arizona Fresh Fruits and Vegetables by Rail and Truck, MRR No. 673. 36 pp.
- Manley, William T. and Godwin, Marshall R. November 1963. Marketing Florida vine-ripened tomatoes--an appraisal by terminal receivers. Florida Experiment Station Circular S-147. pp. 23.
- Podany, Joseph C., Farrish, Raymond O. P., and Bohall, Robert W. November 1963. Packing mature green tomatoes: Quality, costs and margins in the Lower Rio Grande Valley of Texas. MRR-635. pp. 28.
- Chapman, W. Fred Jr., Brooks, Thurston L., and Ford, Kenneth E. July 1964. Vegetable production density--Alabama. Georgia Agricultural Experiment Station in cooperation with ERS. Mimeo Series N.S. 198. pp. 27.
- Chapman, W. Fred, Jr., Brooks, Thurston L., and Ford, Kenneth E. July 1964. Vegetable production density--South Carolina. Georgia Agricultural Experiment Station in cooperation with ERS. Mimeo Series N.S. 204. pp. 26.
- Powell, Jules V. November 1963. Trends in marketing fruits and vegetables. ERS-148. pp. 14.
- Edman, Victor G. February 1964. Prices and price spreads for fresh fruits and vegetables in selected markets, 1956-1962. Stat. Bull. 340. pp. 139.
- Pittman, Jerold F. and Chapman, W. Fred, Jr. February 1964. The organization of the wholesale fruit and vegetable markets in the South--Atlanta, Georgia. South Carolina Agricultural Experiment Station in cooperation with ERS. Agri. Econ. Mimeo 249. pp. 40.
- Pittman, Jerold F. and Chapman, W. Fred, Jr. February 1964. The organization of the wholesale fruit and vegetable markets in the South--Raleigh and Winston-Salem, North Carolina. South Carolina Agricultural Experiment Station in cooperation with ERS. Agri. Econ. Mimeo 250. pp. 47.

- Pittman, Jerold F. and Chapman, W. Fred, Jr. February 1964. The organization of the wholesale fruit and vegetable markets in the South--Columbia and Greenville, South Carolina. South Carolina Agricultural Experiment Station in cooperation with ERS. Agri. Econ. Mimeo 251. pp. 40.
- Hanes, John K. March 1964. The organization of the wholesale fruit and vegetable market in Minneapolis-St. Paul and Duluth-Superior. MRR-647. pp. 45.
- Manchester, Alden C. April 1964. The structure of wholesale produce markets. AER-45. pp. 136.
- Manchester, Alden C. July 1964. The organization of wholesale fruit and vegetable markets in Chicago, Lincoln, Los Angeles, Louisville, Milwaukee, New Orleans, Oklahoma City, Omaha, San Francisco-Oakland, Tulsa, and Wichita. ERS-163. pp. 128.

ECONOMIC AND STATISTICAL ANALYSIS
Economic and Statistical Analysis Division, ERS

Problem.

Because of the instability of the prices he receives and rapidly changing conditions of agricultural production, the farmer stands in special need of frequent accurate appraisals of his economic prospects if he is to plan and carry out his production and marketing activities in an efficient and profitable way. The typical farmer cannot afford to collect and analyze all the statistical and economic information necessary for making sound production and marketing decisions. It is a goal of the Department to provide the farmer with economic facts and interpretations comparable to those available to business and industry. This is accomplished through a continuous flow of current outlook information, the development of longer range projections of the economic prospects for agricultural commodities, and analyses of the economic implications of existing and proposed programs affecting farm commodities.

USDA AND COOPERATIVE PROGRAM

Commodity Situation and Outlook Analysis

The outlook and situation program provides a continuing appraisal of the current and prospective economic situation of fresh and processed vegetables, sweet potatoes, and dry edible beans and peas. Results of these appraisals, and findings of special studies are published in quarterly issues of the Vegetable Situation, the National Food Situation, the Demand and Price Situation, and monthly in the Farm Index. A comprehensive analysis of the vegetable and potato situation is presented at the Annual Outlook Conference. Appraisals also are presented at regional or State outlook meetings, and at meetings of farm organizations and various agricultural industry groups. Special studies are made to determine probable effect of proposed programs on supply, price and consumption of vegetables. Basic statistical series are compiled, improved, and maintained for use in statistical and economic analysis. This work involves 1.5 professional man-years in Washington, D. C.

PROGRAM OF STATE EXPERIMENT STATIONS

For the most part the States depend upon the U.S. Department of Agriculture for the yearly across-the-board commodity situation and outlook research. The State extension staff members supplement and adapt such research information to meet the commodity situation of their States.

Four States have projects that deal specifically with analysis of current price trends and prediction of future prices. There is increasing interest in longer range price prediction because of the growing specialization of farms, which make yearly enterprise shifts less common and less feasible, and which calls for large capital commitments over longer periods of time.

The total direct research effort in the situation and outlook area is approximately 1.7 professional man-years. While not designated as outlook research, much of the research conducted by the experiment stations and reported elsewhere contributes to improved understanding of price-making forces, which in turn improves market situation analysis and price forecasting. Figures are not available on man-hours devoted to vegetable research.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

An article on consumption trends for vegetables was included in the October 1963 issue of the Vegetable Situation. The study indicated that total per capita consumption of vegetables was about stable during the past decade, but that dramatic shifts occurred in the form of use. Consumption in the fresh form declined about 10 percent, while use of processed increased nearly a fourth. Substantial gains were registered in use of both canned and frozen vegetables. With per capita consumption expected to hold near current levels over the next 5 years, and population increasing, a significant expansion in vegetable use is likely. The recent shifts between fresh and processed suggest that a relatively larger increase will occur in the use of canned and frozen commodities.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Kuryloski, Donald S. Vegetable Situation. Published quarterly. ERS, USDA, Washington, D. C.

Kuryloski, Donald S. October 1963. Vegetable consumption trends and prospects. Vegetable Situation, pp. 21-25.

CONSUMER PREFERENCE AND QUALITY DISCRIMINATION--
HOUSEHOLD AND INDUSTRIAL
Standards and Research Division, SRS

Problem. With the increasing complexity of marketing channels and methods, it has become almost impossible for consumers to express to producers either pleasure or displeasure with available merchandise. To market agricultural products more effectively, it is necessary to understand existing household, institutional, and industrial markets and the reasons behind consumers' decisions to purchase or not to purchase. Information is needed on consumers' attitudes toward old and new product forms of agricultural commodities, preferences, levels of information or misinformation, satisfactions or dislikes, and what product characteristics would better satisfy current consumers and/or attract new ones. It is also important to know the relationship between the consumption of one agricultural commodity and another in consumers' patterns of use, the relationship between agricultural and nonagricultural products, and probable trends in the consumption of farm products. Producer and industry groups as well as marketing agencies consider such information essential in planning programs to maintain and expand markets for agricultural commodities which, in turn, increases returns to growers.

USDA AND COOPERATIVE PROGRAM

The Special Surveys Branch conducts applied research among representative samples of industrial, institutional, or household consumers and potential consumers. Such research may be conducted to determine preferences, opinions, buying practices, and use habits with respect to various agricultural commodities; the role of competitive products; acceptance of new or improved products; and consumers' ability to discriminate among selected attributes of a product or levels of an attribute, and the preferences associated with discriminable forms.

The research is carried out in cooperation with other USDA or federal agencies, State experiment stations, departments of agriculture, and land grant colleges, and agricultural producer, processor, and distributor groups. Closely supervised contracts with private research firms are used for nationwide surveys; studies in selected areas are usually conducted by the Washington staff with the assistance of locally-recruited personnel.

The Branch maintains all of its research scientists, who are trained in social psychology or other social sciences, in Washington, D. C., which is headquarters for all the research whether it is conducted under contract or directly by the Branch. The Federal scientific effort devoted to research in this area during the past year totaled 7.0 professional man-years. An additional .2 professional man-year was devoted to research conducted under a transfer of funds arrangement.

PROGRAM OF STATE EXPERIMENT STATIONS

While the State Experiment Stations do not report any of their work in this area, a considerable portion of the work reported in the Economics of Marketing section of this report has similar objectives.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Consumer Preference

Sweetpotatoes. The complete report of results of a panel test to determine household consumer acceptance of a new dehydrated instant sweetpotato flakes, developed by the Southern Utilization Research and Development Division of the Agricultural Research Service, has been published. The test product won the approval of a panel of homemakers in the Washington, D. C., area; the findings have been discussed in detail in a previous progress report.

B. Quality Discrimination

Peas. Two types of canned peas were rated on a preference scale. The experimental peas were treated with 470 ppm methionine, the control peas were standard pack. No significant difference was noted in the mean preference ratings for the two samples.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Hollon, D. S. 1964. Household Consumers' Acceptance of Instant Sweetpotato Flakes. Marketing Research Report No. 663

IMPROVEMENT OF CROP ESTIMATING PROCEDURES
Standards and Research Division, SRS

Problem. The Statistical Reporting Service produces a large number of current statistics pertaining to agriculture. Because of limited resources, statistical methods were devised with a view to producing the most information for the least cost. These methods are subjective in nature and are based largely upon self-selected samples from voluntary crop reporters who fill out and return mailed questionnaires. The information is generally collected in the form of relatives such as acres this year compared to last, and crop condition as a percentage of full crop. Persistent bias is removed by charting, and census or other check data are generally projected to form current estimates. Estimates based on these sample methods have proved relatively satisfactory over the years. However, in seasons when changes are unusually large, the changes may not be fully reflected in the appraisals and reports of the respondents to mailed questionnaires. In situations like this, when accuracy is needed most, the estimates may lack the required precision. Then, when the estimates are translated into available supplies for the different commodities, price inequities may occur and, as a result, producers or the processors of agricultural commodities may suffer serious financial loss.

With the development of modern statistics, new methods based upon probability sampling have been developed. Although surveys based upon probability sampling are more expensive to conduct than the traditional self-selecting mailed survey, these new methods offer a means of increasing the precision and reliability of the estimates. Because of the need by the agricultural economy for high-quality statistics, it is mandatory that the statistical theory and methods be developed and adapted to the collection of agricultural statistics. Some of the new procedures have already been introduced but there is an urgent need for a continuing research to devise efficient survey methods so as to make possible continuing improvement in the quality of SRS statistics.

USDA AND COOPERATIVE PROGRAM

The Department of Agriculture conducts a program of applied research designed to strengthen and improve the methodology used in collecting agricultural statistics. The principal disciplines involved are mathematics, statistics and probability, but other disciplines relating to a particular problem are brought to bear as required. Examples of these are plant physiology, psychology, cartography and photogrammetry. The current program consists of 6.0 professional man-years per year devoted to the study of sample and survey methods, and 4.0 professional man-years working on methods for forecasting and estimating the yields of important crops. Work under this program is done in Washington, D. C., and in SRS field offices located in the States concerned.

PROGRAM OF STATE EXPERIMENT STATIONS

No work reported in this area.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

Onions. Development studies were conducted in Michigan in 1962 and 1963 as a preliminary step in determining the feasibility of objective forecasting of onion yields for the late summer onion crop. A tentative goal would be accurate yield forecasts as of August 1 or later. During 1963 the study was aimed primarily at determining a growth pattern and well-defined bulb development stages that could be used in forecasting final onion weight. In 1962 and 1963 it was determined that the number of plants per unit of area can be estimated by using the row density and distance between rows.

Weekly observations were made from the time of the beginning of bulb formation until harvest. During 1962, two major varieties with different planting dates were observed. Three weekly samples were taken from one planting and two from the other. In 1963, two samples were taken from each of three varieties planted at the same time and two samples taken from each planting of one variety planted at different times.

Evaluation of the development of the bulb through the growing season indicates that both size and weight increase fairly steadily until about 120 days after planting and thereafter at a decreasing rate until harvest.

Time of planting, days after planting, weather, and to some extent cultural practices effect the development of the bulb. Analysis of the data through 1963 indicated that additional data were needed to give stability to the bulb development curve. Also, additional investigation will be necessary to determine, if possible, definite stages of bulb development. One major difficulty in making observations on bulb development is that the plant must be pulled since the above ground portion of the plant does not give adequate information on bulb formation.

The 1964 program is being designed to extend the existing series of data. Location, varieties, and relative planting dates will also be collected on dry matter determination and bud formation within the bulb.